AN ECOLOGICAL STUDY OF WATERFOWL ON ARTIFICIAL IMPOUNDMENTS IN SOUTHERN ALBERTA

by

Lloyd B. Keith

ABSTRACT

During the period from May to August inclusive, 1953 and 1954, studies in waterfowl ecology were conducted on the short grass prairie near Brooks, Alberta. A group of artificial impoundments constructed by Ducks Unlimited was chosen as the study area. Investigation and analyses of aquatic and terrestrial vegetation, soils, predation, nesting cover, population dynamics, and food habits, were undertaken to ascertain waterfowl preferences and other factors affecting duck production.

Vegetative studies disclosed three terrestrial plant communities in the study area, viz., the short grass prairie association, the Juncus community, and the Hordeum community. These were cover-mapped, and quadrats analyzed from each yielded information on species dominance, the effect of grazing, and the potential nest cover.

A survey of aquatic vegetation indicated the presence of a rich and diverse flora. What are believed the first Alberta records of Ruppia occidentalis and Elodea canadensis were found here. The cattail problem was also given consideration, and experiments to obtain a herbicidal control were initiated.

Soils on some portions of the study area were discovered undergoing marked chemical and physical changes due to the accumulation of free salts. The establishment of permanent waters has raised the water-table in the region, and as a result, soluble salts are brought to the surface and deposited by subsequent evaporation. The ensuing changes in plant cover are believed detrimental to waterfowl.

The incidence of nest predation was very high, 58% of the nests being destroyed. Skunks were the principal threat causing at least 65% of the depredations. Duckling mortality as determined from brood counts, amounted to approximately 7%. The most serious form of predation on adult ducks appears to be perpetrated by weasels which killed 3.3% of nesting females.

Nesting cover was shown to be subject to definite selection by ducks. This situation involves both density of cover and particular plant species. It was also noted that the amount of concealment sought by ducks varied from one species to another.

In order to determine population movements, regular counts of adults and broods were conducted. Most adults frequented the larger impoundments in early May, then moved to pothole areas as nesting commenced. During incubation, drakes desert their mates and congregate on mud-flat areas where they loaf and rest prior to departing for the large "moulting lakes". The over-all trend in brood movement is a passage from the smaller to the larger waters.

Stomach analyses disclosed that food habits of adults and ducklings differed considerably, and that distinct preferences are shown for the seeds of certain plant species.

The findings of this investigation are believed to constitute an ecological foundation upon which future management of many waterfowl breeding grounds on the short grass prairie may be based.

THE UNIVERSITY OF ALBERTA

AN ECOLOGICAL STUDY OF WATERFOWL ON ARTIFICIAL IMPOUNDMENTS IN SOUTHERN ALBERTA

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

FACULTY OF ARTS AND SCIENCE

DEPARTMENT OF ZOOLOGY

by

Lloyd Burrows Keith

Edmonton, Alberta,

April 1955

"Search for your God not in the confusion of battle
or behind the smoke of human sacrifices, but amidst
the flowers and trees, the wild duck and the fishes."

1375 B.C.

Akhnaton, father-in-law of
Tutankh-Amen.

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INTRODUCTION

Waterfowl are a major component of our wildlife heritage. The maintenance of an adequate population, in the face of habitat destruction and hunting, has in recent years become progressively more difficult. The present study is but one of a series being currently conducted on waterfowl breeding grounds of western Canada, in a co-ordinated effort to evolve more practical and efficient management techniques.

The R. Howard Webster Foundation of Montreal has given generous financial support to these research projects. Funds are administered through the Delta Waterfowl Research Station, whose parent body is the American Wildlife Foundation.

The objectives of this study were briefly:—to investigate waterfowl preferences as to shoreline type, lake or pothole size, nesting cover, and plant foods, and to determine the various other factors affecting duck production under the artificial conditions established by Ducks Unlimited on the short grass prairie. Studies were initiated in May 1953 near Brooks, Alberta, on a group of Ducks Unlimited impoundments known as the Will J. Reid duck factory.

The study area lies in a region which borders the north-western face of the celebrated Palliser triangle. It will be remembered that this was the area about which heated controversy was waged in the later 1800's. Much of the indecision as to its agricultural potential stemmed from the conflicting reports of those persons expressly enlisted by the British and Canadian governments to explore and ascertain

the agronomic value of this vast tract of land.

During the years 1857-1860 inclusive, Captain John Palliser led a party of competent observers and scientists in the region embracing what is presently the southern half of the provinces of Alberta and Saskatchewan. The primary objectives of this expedition are stated in a letter of instructions received by Palliser from the British Secretary of State (15). . . . "I have to impress upon you the importance, in addition to maintaining a regular series of instrumental observations, of regularly recording the physical features of the country through which you will pass, noting its principal elevations, the nature of its soil, its capability for agriculture, the quantity and quality of its timber, and indications of coal or other minerals."

In reporting the party's findings Palliser referred to a triangular area based on the 49th parallel west from longitude 100 degrees to 114 degrees, and with its apex about 200 miles north of the international boundary near the line which today separates Alberta from Saskatchewan. This region was classified as the "central arid desert" or the "arid belt". Palliser considered this zone unsuitable for cropping but did recognize its possibilities as grazing land, an opinion doubtless prompted by the tremendous herds of bison which native vegetation at that time supported. The soundness of Palliser's recommendations was proved not infrequently in subsequent years and was aptly phrased during the later drought

periods by one resident who complained, "The country should have been left the same side up as God A'mighty made it."

In contradiction to Palliser's views there were the reports of Professor John Macoun who sonorously and relentlessly extolled the virtues of the so-called "arid belt". He discredited Palliser's opinions and went so far as to credit the region with being (21), ". . . one of unsurpassed fertility . . . literally the garden of the whole country."

The apparent explanation for the discrepancy between the findings of these two men rests with the probability that Palliser's impressions were gleaned during a period of dry years while Macoun encountered verdant conditions arising from one or a series of wet seasons.

As may be gathered from the preceding account, prairie weather with its marked effect on the vegetation is neither stable nor predictable. So diverse are conditions from one year to the next that seldom does one hear mention of a typical or normal year. It requires little imagination to envisage the precarious state of waterfowl habitat under these fluctuations. All that can be safely said apropos of weather here is that extremes are the rule and must be anticipated. The variation in temperature between winter and summer is regularly as great as 140°F. The variation in yearly rainfall is frequently no less dramatic; for example, the average precipitation at three stations near the study area during 1927 was 21.89 inches, in 1928 the average precipitation for the

same three points dropped to 9.64 inches (25).

The long-time average yearly precipitation is slightly more than 12 inches. This low rainfall coupled with a high evaporation rate makes grain farming hazardous at the best of times and impossible during drought years. Under these circumstances it is not surprising then that irrigation made its appearance at a fairly early date following settlement of the short grass prairie. One of the largest schemes was developed around Brooks, Alberta in 1910 by the Canadian Pacific Railroad. This enterprise became known as the Eastern Irrigation District.

Today land usage in the short grass prairie region may be broadly classified into three types, viz., irrigation farming that is largely mixed in nature but with some specialty crops being produced, cattle ranching that utilizes large acreages of native pasture, and dry land wheat farming. The latter is by far the least secure undertaking and at present is restricted to the heavier clay soils which are more drought resistant than the coarser textured loams and sands.

A BRIEF HISTORY OF THE STUDY AREA'S DEVELOPMENT

(WILL J. REID DUCK FACTORY NO. 163)

During 1944 Ducks Unlimited was contacted by representatives of the Rosemary Community Pasture and Stringham Brothers. Each of these groups grazed cattle on range land lying east of Gem and north of Rosemary which they leased from the Eastern Irrigation District. This land, while providing fair stands of the nutritious prairie grasses, lacked adequate stock watering sites. It was proposed that Ducks Unlimited undertake a project in this region, drawing waste irrigation water from the Crab Lake spillway and utilizing old service ditches constructed during the early "boom" years of the E.I.D. (1910-1914). These ditches had been abandoned when the soil proved unsuitable for irrigation farming.

The effect of this programme would be twofold; first, much needed stock watering facilities were to be developed; secondly, and naturally of prime concern to Ducks Unlimited, was the promise of another permanent waterfowl breeding area.

Initial surveys were partly completed by Ducks Unlimited's engineer in January 1945. Later the same year this reconnaissance was finished and favorable opinions were formed with regard to the development of a Ducks Unlimited project. Following

suitable negotiations with the parties involved, it was determined that construction work should begin as soon as possible. The estimated cost was set at between ten and fifteen thousand dollars.

Most of the construction was carried out in 1946. However, it was not until September 1948 that the project was officially completed. Although it is not proposed to embark on a detailed account of the work as such, data taken directly from Ducks Unlimited files and listed below are of interest and in part conveys the magnitude of the undertaking:

Improvements

1. Eight earth dams and four dykes with a total yardage of 17,900 cubic yards.
2. Cleaned out and ran to grade 9,400 feet of old service ditch. (These old ditches were remnants of the original C.P.R. irrigation scheme.)
3. Excavated 9,800 feet of new service ditch.
4. Installed one five foot diameter culvert weir and drop.
5. Installed two 12 inch, two 18 inch and one 30 inch culvert controls and three timber controls.
6. Installed five timber drops and five standard culvert drop structures.
7. Installed two timber bridges and one culvert crossing.

8. In the spring of 1948 the temporary timber and culvert control on the Crab Lake spillway washed out and was replaced by a permanent concrete check and drop structure.

9. One and one-half miles of fencing were constructed in 1947.

10. Six and one-tenth miles of scraper trail were constructed.

DESCRIPTION OF THE STUDY AREA

The study area lies in sections 17 and 18, township 23, range 15 west of the 4th meridian; a distance of about 28 miles N.N.W. of Brooks. It is situated on a small plain which is bounded to the west by a low ridge, to the south and east by sand hills, and to the north by irrigated farmland. The soil varies from a sand to a sandy loam and the sole agricultural encroachment is grazing.

This region is particularly suitable for waterfowl ecology studies. Within a limited area are found representatives of the basic habitat types present on the short grass prairie. In conducting the present investigation, the study area was subdivided into four lesser units, designated as A, B, C, and D areas. These differed in size, shoreline vegetation, and composition and density of nesting cover. A map of the study area and each of its subdivisions is presented in Fig. 1. The following is a brief description of the above areas:

A-area:

A series of fenced potholes and their bordering land areas comprises this unit. There are 52 acres contained by the fence, of which 17.2 are free water surface. There are five potholes greater than one acre in size and a number of smaller ones. Maximum depths range from two to six feet and the total shoreline is approximately 5,900 yards.

Cattail (Typha latifolia) growth covers about 80% of the shoreline (Fig. 2); the remaining 20% consists of a Juncus-Carex complex.

The terrestrial vegetation is composed of approximately 23 acres of Juncus community, 6.8 acres of rather atypical short grass prairie association, and 5 acres of cattail.

Livestock have been excluded since 1948, with a single exception which will be discussed later.

B-area:

This is another pothole area and lies next to A-area (Fig. 3). It is unfenced and is about 21 acres in size. There are 18 potholes here, all less than one acre, whose aggregate surface is 3.2 acres. The maximum depth varies from one to four feet, and the total shoreline length is approximately 2,170 yards.

The shoreline cover is largely a Juncus-Carex complex. However, on several saline spots, mud shoreline occurs. No cattail is present.

Of the terrestrial vegetation, approximately 9 acres are short grass prairie association, and 8.8 acres Juncus community.

C-area:

This area consists of two small lakes. Their total surface area is 56 acres, and the adjacent land is grazed. Their maximum depth does not exceed seven feet and the total shoreline length is about 4,080 yards.

Through a combination of saline soils and purposely lowered water levels, these lakes in 1953 provided a mud shoreline free of vegetation (Fig. 4). Unfortunately in the fall of 1953, the smaller of the two lakes was filled to capacity and thus lost for study purposes as a mudflat area.

The vegetation on bordering lands consists of Hordeum community, short grass prairie association, and to a lesser extent, Juncus community.

D-area:

D-area contains a lake of 67.7 acres, whose maximum depth is eight feet. The surrounding land is grazed. Total shoreline here is approximately 3,580 yards.

The shoreline cover is composed largely of a Juncus-Carex complex; five small islands in the lake, however, have cattail shorelines (Fig. 5). It should be mentioned also that a sizable stand of Scirpus validus grows as an emergent, having been planted by Ducks Unlimited.

The vegetative cover of the adjacent land is primarily short grass prairie association and Juncus community.

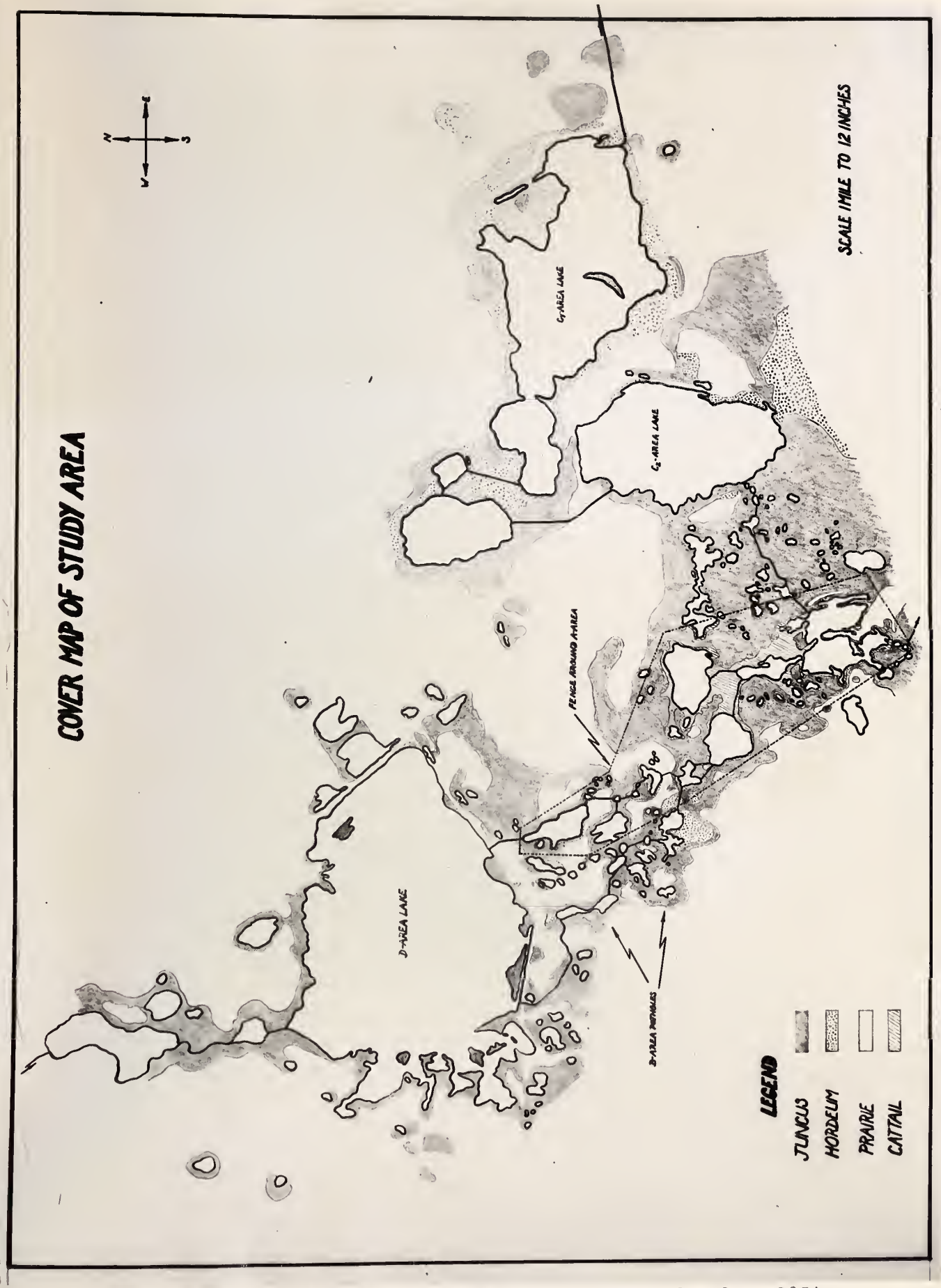

Fig. 1. Map of study area showing plant communities: water levels - 1954.

Fig. 2. An A-area pothole showing dense stands of Cattail: note also tree growth in background.

Fig. 3. The potholes of B-area: A-area fence to left.

Fig. 4. The mud shoreline of C-area lakes.

Fig. 5. A section of D-area lake showing Cattail on ungrazed islands.

TERRESTRIAL VEGETATION

An analysis of the terrestrial vegetation was undertaken as one phase of the present study. The principal objectives of this particular investigation were: first, to determine the relative abundance of those species comprising the area's plant communities, secondly, to map accurately these communities (Fig. 1), and thirdly, to determine the effect of grazing on the vegetation in general.

Knowledge of this nature furnishes an essential and basic contribution to the building of an ecological foundation from which the various manifestations of species preference can be interpreted. Particularly valuable is its contribution, when correlated with certain findings of the nesting study, to an understanding of the factors involved in the selection of nest cover.

Procedure:

A cursory examination of the study area indicated the presence of three major plant communities:

1. A modified short grass prairie association, on the drier plains and hills.
2. A *Juncus* community (mainly *Juncus balticus*), on the periphery of fresh water potholes and lakes, and in other damp non-saline places.

3. A Hordeum community (mainly Hordeum jubatum), on moist saline areas.

In order to carry out a more detailed inspection it was necessary to analyze a number of quadrats from each of the aforementioned areas. Since it was not proposed that this be a highly refined analysis, a minimum of sampling was conducted. On grazed and ungrazed locations in each community, sites were selected which were thought to embrace a typical flora. Permanent marker stakes were then driven into the ground.

A yard-square quadrat frame was constructed which was subdivided into nine square feet by a series of cross wires. By pivoting this metal quadrat around each marker stake, it was possible to cover four square yards or thirty-six square feet, (Fig. 6). These four positions were numbered as were the nine, foot-square subdivisions within each, (Fig. 6). In order to determine which foot-square quadrat would be analyzed each month at any one location, the procedure was as follows:

1. The numbers one to four were written on slips of paper and placed in a container; a number was drawn at random thus selecting one of the four positions around the marker stake.
2. A draw was next made from another container in which were numbers one to nine. The number obtained this time delimited the

particular foot-square quadrat to be sampled within the previously determined position. If for example the first number chosen was two and the second five, the location of the quadrat would be as illustrated in Fig. 7.

Having carried out the above steps, and thereby determining the exact location of the quadrat, the quadrat frame was placed in position and the designated vegetation clipped off at ground level. This material was taken indoors and all vegetative stalks of one inch or longer classified as to species and grouped accordingly.

Identification of the various species was based mainly on vegetative characters, as few specimens possessed floral parts. The technique used is essentially that described by Clarke (5), and can only be mastered with practice.

After a complete segregation into species was completed, a tabulation was made of the species found and the number and average height of their vegetative stalks. The latter figure was obtained by aligning cut bases of the vegetation, estimating the mean height, and measuring this distance with a ruler.

Examination of the vegetation was carried out at monthly intervals during most of the growing season. In 1953, quadrats were analyzed at the end of July and August, while in 1954 they were analyzed at the end of May, June, July and August.

In order to ascertain species dominance, the number of living vegetative stalks of a species in a quadrat was multiplied by their average height.* The figure thus obtained represents total vegetative length, a working basis from which species dominance may be computed.

In addition to the more exacting technique of analysis through quadrats, a general list of all plants found was compiled. These will be found in the appendix under the headings: "Plants of the Short Grass Prairie Association", "Plants of the Juncus Community", etc., and classified as major, common, and occasional.

Results and Conclusions:

The Short Grass Prairie Association

Species Composition. Table I summarizes the composition of the short grass prairie association as obtained from quadrats on the study area. In conjunction with these results are those presented by Clarke (3), from four other regions on the short grass prairie.

Several conclusions may be drawn from these data. The dominant plant species in the short grass prairie association of the study are; Bouteloua gracilis, Carex spp., and Stipa comata. Subdominant species are Koeleria cristata, Calamovilfa longifolia, and Agropyron Smithii. Because it is frequently impossible to distinguish Stipa and Koeleria vegetatively during early growth, some question does arise as

* This procedure was approved by Dr. E. H. Moss, Professor of Botany, University of Alberta.

to the relative composition of the aggregate percentage given in Table I. Moss (19) shows graphically a ratio of approximately 2 / 1 favoring Stipa comata, while Clarke (3) presents an exact 2 / 1 ratio. It is believed that a similar condition prevails on the study area. This opinion is not entirely subjective for an analysis of eight quadrats taken from a burned section of prairie near here in 1954 yielded a ratio of 2.2 / 1. These quadrats, however, are not included in the present research and are merely cited by way of illustration.

A comparison of the two columns in Table I reveals several differences between the typical short grass prairie as reported by Clarke(3) and the modified association of the region involved in this study.

There appears to be a distinctly higher proportion of Bouteloua gracilis on the study area than is present in other localities.

The percentage of Agropyron Smithii was far less than that which might be considered the norm. Since this species does best on clay soils (19), the lighter soils of the study area are doubtless in part responsible for this decreased stand. It was noticed in traversing the area, that the greatest concentrations of this grass occurred on slightly alkaline sites, particularly where erosion had removed a good deal of the top soil. Similar observations have been recorded previously by Clarkeand his co-workers (4) (5).

The presence of Calamovilfa longifolia simply reflects the sandy nature of the local soils. It is a common constituent of short grass prairie vegetation wherever suitable edaphic conditions occur.

TABLE I

SPECIES COMPOSITION OF THE SHORT GRASS PRAIRIE

Species	% Comp.* on study area (20 quadrats)	% Comp.* as reported by Clarke**
Bouteloua gracilis	32.5	21.6
Stipa comata Koeleria cristata	31.9***	27.5
Carex spp. C.heliophila C.eleocharis C.Douglasii	20.7	17.1
Calamovilfa longifolia	5.1	--
Agropyron Smithii	4.9	20.4
Poa secunda	--	6.4
Stipa spartea	--	2.6
All other species of plants	4.9	--
Other grasses and sedges	--	4.4
Total	100.0	100.0

* Based on total vegetative length.

** These percentages do not take into account plants other than grasses and sedges, whereas the percentages for the study area in the first column were computed with forbs included. This factor is of minor consequence, however, since the number of forbs in the study area quadrats were rather incidental.

The figures in this column are not quoted directly from Clarke's paper but were arrived at by combining data from two of his tables.

*** Stipa comata and Koeleria cristata are grouped together due to the difficulty in distinguishing the two species by vegetative characters. A reliable estimate of the ratio of Stipa to Koeleria would appear to be 2 / 1 respectively.

Poa spp., although ubiquitous on the study area, are minor constituents of the vegetative cover. The chief species found here are Poa arida, Poa secunda, and Poa Cambyi. Stipa spartea was not recorded in the region during the two years of this investigation.

Differences in the percentages of Stipa comata, Koeleria cristata, and Carex spp. between the columns of Table I are slight and probably not significant. In corresponding so closely with one another they do, however, add significance to the more pronounced differences mentioned previously in connection with other species.

One further point should be mentioned apropos of the short grass prairie association, viz., the presence of Agrostis scabra on the moister sections. This grass forms a webby, reddish colored inflorescence at anthesis which dominates large patches of low prairie. An analysis of twelve quadrats from such areas revealed a transitional vegetation composed of 32.3% Agrostis scabra.

Effect of Grazing. The Rosemary community pasture consists of several large fields. The largest of these and the one on which the study area is located comprises 10,000 acres. For the past several years this field has served as a summer and fall breeding pasture, cattle being turned in on the first of July and taken out prior to the end of December. Weather conditions do of course affect the later date. Livestock have been removed as early as mid-November and as late as mid-January. In 1953, 1,700 cows, bulls and yearlings ranged this area, while in 1954 the number totaled 2,000 head. Animals are wintered

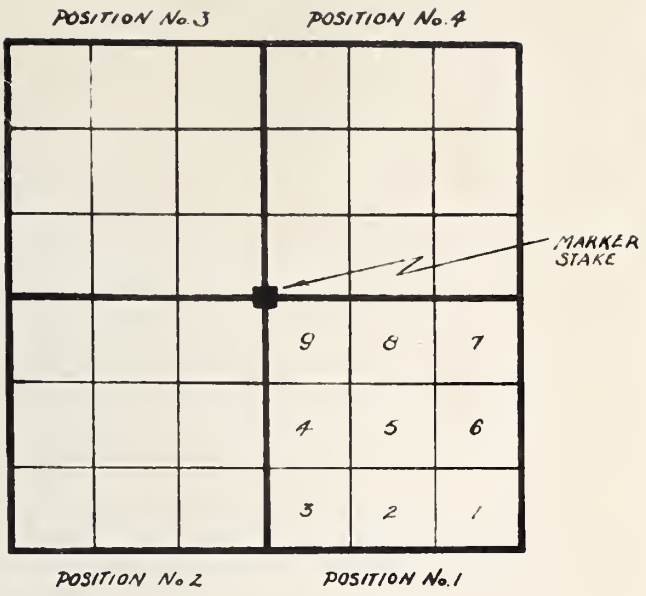

Fig. 6. Positions of quadrat frame around marker stake.

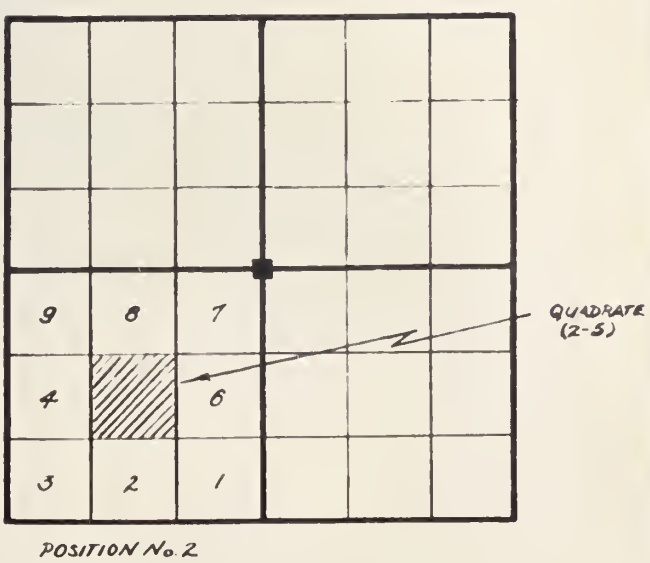

Fig. 7. Position of quadrat (2 - 5).

on farms in the irrigated districts and in the spring are again returned to the range. Fields utilized from early spring until July first are known as calving pastures as most young are born here.

Range management of this type has a particularly important bearing on waterfowl. When fall pastures are heavily grazed or when drought conditions prevail, the vegetative cary-over from year to year may be nil. This can be of serious consequence to early spring nesters which are entirely dependent on the preceding year's growth for nesting cover. Those areas used regularly as spring pasture generally suffer far less destruction, as old growth is ignored by livestock the moment new cover appears, and summer growth is unimpaired since livestock are pastured elsewhere.

In laying out quadrats on grazed and ungrazed sections an attempt was made to assess the influence of cattle on the vegetation. Unfortunately, a number of factors intervened which largely defeated the plan. To begin with, rainfall during the past two summers was well above normal (Table II) resulting in an unprecedented growth on native grasslands. As the number of cattle grazing here was somewhat below the carrying capacity of the range under such conditions, differences between grazed and ungrazed areas were minimized. Furthermore, livestock had access to all quadrat positions during the late fall, hence any endeavour to measure the yearly accumulation of vegetation in areas free from cattle during the previous summer was negated.

Despite these difficulties sufficient data were obtained in 1954 to serve as at least a partial indication of the effect of grazing on the study area (Table III). This Table shows that livestock were unable

TABLE II

TOTAL RAINFALL MAY TO AUGUST INCLUSIVE
BROOKS, ALBERTA

Long-time ave. (20 years)	1953	1954
6.83 inches	11.89 inches	9.80 inches

TABLE III

THE EFFECT OF GRAZING* ON THE PRAIRIE ASSOCIATION
OF THE STUDY AREA 1954

Situation	Date	Veg.	Situation	Date	Veg.	Ratio of Increase
Ungrazed	May and June	1077**	Grazed***	July and Aug.	1303	1.21
Ungrazed	May and June	1373	Ungrazed	July and Aug.	2351	1.76

* Grazing intensity -- 2.50 acres per animal per month.

** Average total length in inches of vegetation per quadrat.

*** Grazing commenced on July 1.

to prevent an over-all increase in vegetation during the summer months of July and August. The situation is quite likely exceptional, a product of two consecutive years of above average precipitation. As will be noted, however, a greater increase did occur on ungrazed sites. Fig. 8 compares grazed and ungrazed sections of the short grass prairie association.

The Juncus Community

Species Composition. The composition of the Juncus community is presented in Table IV. Juncus balticus completely dominates this community, comprising over 85% of the vegetative cover. The only other notable species are Hordeum jubatum, and Carex spp. (mainly Carex praegracilis), whose total contribution is less than 13%. It is rather interesting that of the prairie grasses, Agropyron Smithii is the sole intruder on this community. This situation also occurs in the Hordeum community. Juncus balticus thrives on damp to wet non-saline soils; it is, however, quite tolerant of saline and alkaline conditions.

Effect of Grazing. Since the chief component species of this plant community are unpalatable to livestock, no significant differences were found between grazed and ungrazed quadrats.

The Hordeum Community

Species Composition. The Hordeum community is an appellation chosen to describe a group of plants inhabiting saline soils. These

Fig. 8. Effect of grazing on the short grass prairie association: left of fence grazed, right of fence ungrazed.

TABLE IV

SPECIES COMPOSITION ON THE JUNCUS COMMUNITY

Species	% Comp. on study area (24 quadrats)
Juncus balticus	85.8
Hordeum jubatum	8.7
Carex spp.	3.7
Agropyron Smithii	0.7
Other species	1.1
Total	100.0

TABLE V

SPECIES COMPOSITION ON THE HORDEUM COMMUNITY

Species	% Comp. on study area (20 quadrats)
Hordeum jubatum	76.5
Distichlis stricta	12.5
Agropyron Smithii	4.1
Spartina gracilis	1.5
Juncus balticus	1.2
Puccinellia Nuttalliana	0.3
Triglochin maritima	0.3
Others	3.6
Total	100.0

soils are commonly known as alkali, but actually may or may not be alkaline in reaction. As Rawson and Moore (20) point out, the pH of lakes locally described as alkaline is frequently only slightly so and thus the term saline is more applicable.

There appears to be an instability within this community which is much more pronounced than in the other vegetative types. Even in the short span of the study, pronounced fluctuations were noticed in plant species on portions of the Hordeum community. As far as can be ascertained, thesedynamics are a reflection of soil changes resulting from an ever increasing accumulation of free salts in the strata penetrated by plant roots. Since this and related phenomena are discussed in a subsequent section on soils, the subject will not be pursued further at this point.

Table V summarizes quadrat information from this plant group. The species listed all tolerate varying degrees of salinity. However, they should by no means be accepted as the most tolerant. Such species as Salicornia rubra, Chenopodium salinum, and Suaeda depressa must be elevated to this position.

Effect of Grazing. Hordeum jubatum is quite unpalatable during the summer months, and livestock produced no discernible impression on stands of this species. It is said by local cattlemen, however, that spring growth is relished before this grass's scabrous properties become pronounced. By late fall, the awned inflorescence has generally broken off and blown away, when the plant is again eaten but not in

quantity. Distichlis stricta is described by Hitchcock (10) as being, ". . . grazed when better grasses are not available." It is not surprising then that quadrats yielded no suggestion of decreased stands on grazed areas of this plant community.

Summary:

1. Analyses of the terrestrial vegetation on the study area were carried out during the summers of 1953 and 1954.
2. Three main plant communities were recognized:--the short grass prairie association, the Juncus community, and the Hordeum community.
3. Using quadrats, species composition and dominance were investigated. The short grass prairie association was shown to consist of a Bouteloua-Carex-Stipa complex, of Bouteloua gracilis, Carex spp., and Stipa comata. Subdominants were:--Koeleria cristata, Calamovilfa longifolia, and Agropyron Smithii. The Juncus community was determined to be about 86% Juncus balticus and 9% Hordeum jubatum, while the Hordeum community is over 76% Hordeum jubatum and 12% Distichlis stricta.
4. Grazing was found to exercise a significant effect in the short grass prairie association, but on neither of the other plant communities.
5. A cover map was drawn up showing the distribution of the three plant communities on the study area.
6. A list of all plant species identified in the region was assembled and is presented in the appendix.

AQUATIC AND EMERGENT VEGETATION

An examination of the aquatic and emergent vegetation was conducted on the study area. Such knowledge is often fundamental to an understanding of certain phases of waterfowl behaviour and preference.

It is impossible to forecast the plant species located here, for, in flooding previously arid prairie, new plant successions are initiated, the products of which are inextricably dependent on a multitude of factors. These factors may include soil type, pH, and salinity: source of water, nearness to old permanent water bodies, chance dispersal by birds and mammals, and Ducks Unlimited plantings, to mention but a few of the more obvious variables.

Two current problems facing Ducks Unlimited in the management of projects and involving aquatic and emergent species are: the total choking of shallow impoundments by cattail, and the value and efficacy of planting programmes to provide food and emergent nesting cover. In studying this plant community, these problems were not forgotten and through objective observation and experimentation, the points in question were investigated.

Procedure:

Supplementing routine observation and inspection in this phase of the study, several planned experiments were conducted. The most ambitious of these was an attempt to discover a herbicidal means of

controlling cattail.

In 1954, three banks, each containing 28 randomized plots (10 ft. x 10 ft.), were set up in a pothole area which was rapidly succumbing to a vigorous growth of cattail. Six different treatments were applied using 2-4D and Dalapon.* The treatments were as follows:

1. 25 lbs. of 2-4D per acre, (active ingredient)
2. 50 lbs. of 2-4D per acre, " "
3. 10 lbs. of Dalapon per acre, " "
4. 20 lbs. of Dalapon per acre, " "
5. 25 lbs. of 2-4D per acre and 10 lbs. of Dalapon, (active ingred.)
6. 50 lbs. of 2-4D per acre and 10 lbs. of Dalapon, " "

One of the banks of plots was sprayed on June 23, another on July 22, and the third on both dates. Yard-square quadrats were analyzed from the centre of each plot on August 21, the number of living vegetative stalks and their average height being recorded.

On a limited scale attempts were made to measure the rate at which cattail and roundstem bulrush (Scirpus validus) spread vegetatively through shallow waters. A number of quadrat positions were also set up in mixed beds of cattail and roundstem bulrush to determine whether sufficient inter-species competition existed to result in the gradual reduction and eventual extermination of one species.

Results and Conclusions:

Species Composition: In tramping the shorelines and wading the shallow waters of the study area's impoundments, two features become

* Sodium 2,2 - dichloropropionate, a product of Dow Chemical Co.

rapidly apparent. First, that there are striking differences in the aquatic and emergent flora of fresh and saline waters; secondly, that these small lakes and potholes contain a rich and diverse plant growth. When one considers the short period of time these bodies of water have existed (seven to eight years), some of the findings are quite remarkable.

Although the actual salt concentration in these waters is unknown, impoundments classified as saline were obviously so, for their shoreline soils were found to contain greater than 1% free salts. The salt content of shoreline soils from fresh water impoundments was negligible. Rawson and Moore (20) show correlations between the salinity of lakes in Saskatchewan, and the various aquatic species found therein. A summary of the differences in plants of saline and fresh waters on the study area is presented in the appendix. One of the most prominent differences is the reduced growth of Potamogeton spp. in the saline waters. This may be of considerable importance to waterfowl since seeds of these plants are widely utilized for food.

Collections made in the area during 1953 and 1954, produced two interesting records, viz., Canadian waterweed (Elodea canadensis) and western widgeon grass (Ruppia occidentalis). Each was a new addition to the Herbarium of the University of Alberta, and as far as can be determined, are the first collections of these plants in the province. During the past two years a total of 29 species was collected from

the waters of the region, including seven species of Potamageton.

In their planting programme, Ducks Unlimited introduced to the area roots or seeds of the following plants: (1) Wild rice (Zizania aquatica), (2) Sago pondweed (Potamogeton pectinatus), (3) Three-square bulrush and (4) Roundstem bulrush. The first two are food species while the latter were planted primarily to provide emergent nest cover for diving ducks. With the exception of wild rice all are indigenous to the province and would probably have invaded the area sooner or later without direct human assistance. In Canada, wild rice does not occur west of central Manitoba and its introduction to the study area is indeed of interest. Reports by Ducks Unlimited personnel subsequent to its planting indicate that the wild rice did remarkably well for two years, then was winter-killed. Since this primordial stand was exposed to heavy grazing, a factor which greatly reduces the over-winter survival of most grasses in this severe climate, it would be well to repeat this introduction, utilizing fenced areas to provide protection from livestock.

The Effect of Herbicides on Cattail. The results of the herbicide experiment are very encouraging as complete kills were recorded frequently by mixtures 5 and 2 (p. 30). However, since regrowth of this species may occur next year, it would be fallacious to draw conclusions at this time as to the permanency of destruction. Further quadrats will be analyzed during the summer of 1955 and at this time more evidence should be available on the success of the experiment.

Cattail - Bulrush Growth and Competition. The rate at which cattail spreads vegetatively through shallow waters is estimated by the observer at approximately three feet per growing season. At six marked positions on the study area, the average yearly gain was thirty-one inches. It is believed these figures are conservative. During the same period an equal number of marked roundstem bulrush stands increased their edge by less than six inches. From quadrats in mixed beds of roundstem bulrush and cattail, no indication was secured of one species supplanting the other in the hydrosere. Roundstem bulrush can, however, grow from depths of at least four feet, whereas in the same region cattail is limited by a depth of less than three feet.

The Effect of Grazing on Cattail. The inherent ability of cattail to pioneer an area has long been recognized and it is interesting to review the records of Ducks Unlimited projects and note the rapidity and ease with which it invaded these undertakings. The downy seeds of the plant are doubtless borne by both wind and water to such areas. It is highly probable too that even prior to flooding, large sections of prairie have the latent capability in the form of myriads of dormant seeds, to produce cattail growth. A possible herbicidal control for cattail has been previously discussed. There are two biological factors which may also tend to limit its growth; these are grazing by livestock and the activities of muskrats.

On the study area the only shorelines having permanent beds of cattail are those which are inaccessible to cattle. Where effective

fencing exists, or where islands occur to which cattle cannot easily wade, dense stands flourish. The fence in Fig. 9 has excluded grazing animals for six years. Note the tremendous contrast in growth on each side of this barrier. Cattail is not of course the sole benefactor from fencing, for willows and poplar soon become established, and palatable forbs and grasses increase in height and density.

On the basis of two years' observations it is suggested that grazing offers an efficient, practical, and economical means of restricting cattail growth. The following reservation is interjected, however, provided shorelines are grazed each summer. The reason for this limitation becomes apparent in an examination of the method by which the writer believes cattail establishes itself in new impoundments.

The first signs of growth occur in the littoral zone. It is probably in this ecological niche that seed germination and development is favoured. Over the growing season these incipient stands rapidly consolidate, developing a vigorous and prolific network of roots and rhizomes. The encroachment of deeper waters is next accomplished vegetatively by the underground organs, which spread until the limiting depth is reached.

If the above interpretation is correct, it is clear that early cattail development occurs on sites accessible to cattle, viz., the shoreline. Should young plants be grazed at this time, subsurface growth is likewise curtailed and vegetative propagation greatly impeded or prevented entirely. Since cattail is palatable during early growth, livestock do regularly eat it and hence severely discourage its permanent

Fig. 9. Fence through pothole and low ground: note willow and cattail growth in ungrazed area on left side of fence.

Fig. 10. Muskrat and muskrat cuttings in stand of round-stem bulrush, D-area lake.

establishment. If, however, stands are allowed to develop to a point where tenacious footholds are obtained in the deeper waters, cattle are no longer a serious menace to the stands.

Role of the Muskrat. There are numerous citations in the literature of muskrats exerting a pronounced effect on cattail. In some instances these mammals are reported to have wiped out large areas then moved to other marshes (14). Muskrat populations on the area investigated could not be charged with similar tendencies. Although the population was very high, for example, 113 rats were removed from a 68 acre lake in 15 days, their influence on cattail was almost undiscernible. While it is true that an inspection of cattail beds yielded evidence of chewed stalks and leaves, it would be erroneous to say that muskrats were controlling cattail. This situation cannot be attributed to the depredations of a small muskrat population on a large cattail stand, since cattail growth here was restricted to five small islands, around which centred most muskrat activity.

Muskrats in the area generally utilize dam, dyke and bank burrows: typical rat houses are seldom seen. This may partially account for the slight cattail destruction.

With roundstem bulrush an entirely different condition prevails. Muskrats displayed a distinct preference for this species as food and swam considerable distances to obtain it. As was indicated earlier, Ducks Unlimited planted roundstem bulrush for the express purpose of providing emergent nesting cover. The most extensive plantings were

conducted in the largest lake on the study area, at depths of three to four feet. At the present time, six years later, its waters are dotted with patches of bulrush ten to twenty feet square, theoretically excellent locations for the nests of diving ducks. Unfortunately such is not the case, for muskrats keep this growth thinned (Fig. 10) to the extent that grebes and terns are the sole nesters. In the evening one may observe a steady procession of rats converging on stands of bulrush from dyke and island runways. Their return journey is invariably conducted with a mouthful of bulrush stems.

To conclude this brief account on the muskrats it is probably timely to indicate they are also serious pests to those responsible for the maintenance of earthen dams, dykes, etc. Their gnawing propensities enable them to penetrate even wooden structures and control gates. In 1954 muskrats caused a major wash-out on the main ditch supplying the study area. On this occasion it took several days labour and a considerable sum of money to repair the damage.

Summary:

1. An investigation of the aquatic and emergent components of the area's vegetation was conducted and a summary of the findings is presented in the appendix. It was noted that to a considerable degree, distinctive floras characterized fresh and saline waters.
2. The impoundments of the study area were found to support a rich and varied growth of plants, two species of which

are believed new records for Alberta.

3. Studies were made on cattail with special reference to herbicidal control, effect of grazing, and method and rate of spread. While the final results of the herbicide experiment must await further observations, it is felt that yearly summer grazing of incipient stands of cattail will effectively prevent their establishment.

4. The status and influence of the muskrat is also discussed briefly and it is suggested that these mammals prevent important stands of roundstem bulrush from becoming attractive nesting sites.

SOILS

The area's flora has been previously discussed and the effects of its soil's sandy texture and recurrent saline spots briefly noted. Persons are frequently inclined to question the connection between soils and waterfowl. Directly, there is very little; indirectly, through the medium of plants, soils have a profound influence. The nature and properties of soils may determine, for example, the availability of food, both plant and animal, the quantity and species composition of nesting cover, and numerous other factors of importance to waterfowl. Many of the latter are individually imperceptible but when considered in the aggregate possess significance.

Procedure:

Soil samples were collected during the summer and subsequently analyzed in the laboratory of the Soils Department at the University of Alberta. A composite sample was taken from a number of sites in each plant community, and from other locations which were of interest for reasons discussed later. These soils were immediately air dried to discourage further chemical and biological activity.

Determinations of pH, total soluble salts, and free ions were made. The pH was obtained with a type of potentiometer commonly utilized by pedologists for this purpose. A Wheatstone Bridge apparatus was used to measure total soluble salts, and a detection of the free ions was conducted employing the standard qualitative precipitations.

Results and Conclusions:

Physical Properties of the Soil. Soils of the study area vary in texture from sands to sandy loams. There are some small patches of bentonitic clay present, but these are scattered and unimportant. Several blow-outs are found on the area, which were initiated by ditching operations in the early years of the Eastern Irrigation District's development. Average precipitation, as explained before, is very low and even minor vegetative destruction when combined with wind can result in the formation of extensive blow-outs.

Burn-out spots are common on the higher ground; on these sites most of the top soil has been eroded by wind or water, leaving the parent material exposed. Their size may occasionally approach that of a city lot. Plant growth on burn-outs is sparce and composed largely of Agropyron Smithii.

Chemical Properties of the Soil. Some chemical properties of the soils under the major plant groups are contained in Table VI. It will be noted that soil in the Hordeum community yielded the highest concentration of soluble salts, a condition forecasted earlier on the basis of plant indicators. An example of the sensitivity of plants to soil properties is given in Fig. Il and its accompanying Table VII. This pronounced demarcation of species appears to reflect salinity and alkalinity, although moisture may affect the situation somewhat. The presence of Calamovilfa longifolia in the short grass prairie association provides another relevant example of a plant

TABLE VI

AN ANALYSIS OF SOILS BENEATH THE MAJOR PLANT COMMUNITIES ON THE STUDY AREA

Vegetation	pH	Wheatstone Bridge Reading	% Salts	Ions Ca	Mg	Na	SO_4	Cl
Short grass prairie assoc.	6.4	1020	neg.*	-	t	-	-	t**
Juncus community	8.1	860	neg.	t	t	-	-	t
Hordeum community	7.7	210	0.3	+***	++	+	+	+

* negligible

** trace

*** positive, more than trace.

Fig. 11. Differences in plant cover as a result of soil conditions: A - Sonchus arvensis, B - Hordeum jubatum, Distichlis stricta, C - Puccinellia Nuttalliana.

TABLE VII

AN ANALYSIS OF SOILS BENEATH THE VEGETATION DEPICTED IN FIGURE 11

Key Letter	pH	Wheatstone Bridge reading	% Salts	Ions Ca	Mg	Na	SO_4	Cl	Moisture
A	8.5	500	neg.*	-	-	-	-	t**	damp
B	9.6	161	0.7	-	-	t	-	+***	moist
C	10.0	65	>1.0	t	t	++	-	+	wet

* negligible

** trace

*** positive, more than trace.

indicator, in this instance as an indicator of soil texture. The various theories and applications of plant indicators are thoroughly discussed by Clements (6).

A consideration of saline and alkaline soils seems appropriate at this point. It is advisable first to define the terms saline and alkaline. In a recent publication by the United States Department of Agriculture (23) three related soil types are recognized and described. Table VIII summarizes this information. It is clear from Table VIII that there are soils which are saline and not alkaline, and conversely soils which are alkaline and not saline. Saline-alkaline soils also exist, and as the term implies are both saline and alkaline. These saline-alkaline soils may evolve into typical alkaline soils; for if the free salts are leached out of the profile, sodium ions dissociate from soil micelles and react with water to produce sodium hydroxide. Sodium hydroxide then reacts to produce sodium carbonate and a subsequent rise in pH.

Saline-alkaline and saline soils are found on the study area. There are definite indications, which will be discussed later, that a rapid transformation of neutral, non-saline soils to these states is occurring. A marine shale from the Upper Cretaceous known as the Bearpaw formation is the parent material from which the area's soils have weathered (25). It is natural then to expect the presence of some free salts. However, because of the soil's sandy texture and consequent high permeability, most salts have long been leached from the surface

TABLE VIII

THE PROPERTIES OF SALINE, ALKALINE, AND SALINE-ALKALINE SOILS*

Soil type	pH	Total soluble % salts**	Total exchangeable sodium %
Saline	<8.5	>0.8	<15
Saline-alkaline	seldom >8.5	>0.1	>15
Non-saline alkaline	>8.5	<0.1	>15

* From Ref. (23)

** These percentages represent derivations from a different method of expressing total soluble salts used in (23).

and out of the zone of root penetration. Hence, typical native vegetation (short grass prairie association) contains no halophytic species. In undrained depressions where the water table is at or near the surface, salts leached from surrounding land are destined to accumulate. On such areas saline and alkaline conditions may develop. Plant growth generally begins to be affected when the soil's free salt content reaches 0.1% (23).

Soil Changes on Study Area. When the water table is raised, a movement of soluble salts, diametrically opposed to the leaching process occurs. Salts dissolved from the parent formation are brought to the surface with rising ground water and deposited by evaporation. It is believed this situation is prevalent on the study area, having been induced by the damming and dyking of natural spillways. When the study was begun, no direct provisions were made to measure vacillations in soil chemistry. Several pertinent observations were recorded, however, which together with laboratory analyses have corroborated the above view.

It was first observed in the spring of 1954 that at one of the quadrat positions in the Juncus community (S_1), plants were starting to die. By the end of the summer much of the ground was barren, Fig. 12. Table IX presents a comparison of data between soil supporting typical Juncus growth and soil from quadrat S_1. In light of this information the decimation of Juncus balticus can probably be attributed to its limiting salinity having been surpassed in the soil solution.

Fig. 12. Vegetation dying in vicinity of quadrat S_1 on the Juncus community.

TABLE IX

A COMPARISON OF SOIL BENEATH TYPICAL JUNCUS COMMUNITY GROWTH AND THAT FOUND AT QUADRAT S_1

Vegetation	pH	Wheatstone Bridge reading	% Salts
Typical Juncus community	8.1	860	neg.*
Quadrat S_1	7.8	258	0.3

* negligible

In the fenced portion of the study area, dense cattail growth encircles each pothole. By mid-summer of 1954 it was apparent that a strip of cattail about fifteen to twenty feet wide and one hundred feet long on the edge of one particular pothole had failed to grow. It was as if a swath had been cut through the middle of the stand (Fig. 13). During the previous year a luxuriant growth had covered this site. Now all that remained as evidence was an array of dead stalks and an occasional stunted plant. An analysis of the soil here yielded the highest concentration of soluble salts yet recorded on the study area, viz., a Wheatstone Bridge reading of only 17, representing well over 1% salts. The pH was 8.2, consequently this is a typical saline soil. Unfortunately comparative data are unavailable from adjacent soils supporting good cattail growth. It is strongly suspected, however, that the condition was provoked by soil salination.

There remains one additional piece of local evidence indicative of a rapid accumulation of free salts in the surface soils. In the course of a year and a half, a section of road has become impassable to vehicles. In the spring of 1953 it appeared as normal as the remainder of the trail is today. By August 1954, it had become a bottomless mire when wet and a dazzling salt flat when dry. Traffic must now swing well away from the original track as an ever increasing area is affected. In Fig. 14 the individual is standing on the old trail, to the left may be seen the concentric routes of subsequent passage.

Fig. 13. Swath of cattail which failed to grow in 1954 on the edge of an A-area pothole.

Fig. 14. A low section of road becoming impassable due to "alkali" development.

The Significance of Soil Changes to Waterfowl. The effect of these soil changes on waterfowl is presently unknown, however, any great replacement of Juncus community and short grass prairie association with Hordeum community species is suspected to be unfavourable. This opinion, as will be seen later, is based on two observations; first, nesting densities were lowest in the Hordeum community, secondly, this plant community contains no important food species.

The problem of salt accumulation in surface soils has been fought for years by farmers and engineers. Various techniques to reclaim "alkali" land in irrigation schemes have been devised, but many of these are too costly to have wide application and many are only temporary solutions. In recent years, soil surveys have preceded irrigation developments, and areas found to be potentially saline or alkaline have been strictly avoided. This procedure has proved very successful and is now invariably employed wherever irrigation is proposed.

Since similar factors are involved in salination whether it be on irrigated farmlands or around Ducks Unlimited projects, it follows that soil surveys of prospective "duck factories" could be instrumental in preventing this condition.

Summary:

1. A physical and chemical appraisement of the region's soil was made with analyses conducted in the soils laboratory at the University of Alberta. It was

discovered that pH ranged from 6.4 on the short grass prairie association to 10.0 on some saline-alkaline sites. Free salt content of soils varied from negligible to well over 1%.

2. A brief discussion of plant indicators is presented and relationships between several plants and the chemical properties of their edaphic environment is outlined.

3. The evolution of some neutral, non-saline soils of the study area, to a saline-alkaline state is indicated and several pertinent examples are submitted and discussed.

4. It is thought that wide spread salination would be detrimental to waterfowl, and that soil surveys of proposed Ducks Unlimited projects may be advisable to avoid this situation.

PREDATION

Few other birds or mammals must contend with the large and diverse number of predators which constantly harass waterfowl. Crows, magpies, gulls, ground squirrels, badgers and snakes eat eggs; hawks, owls, mink and weasels prey on adults and young; while coyotes, foxes and skunks are a threat at all times.

Nature has invested waterfowl with two principal means of counteracting the forces of predation; a large clutch size, and the ability to renest. Prior to man's intervention, these were sufficient to compensate natural losses and maintain a high population. Unfortunately, this situation has been upset by the drainage of marshland and ever increasing hunting pressures. In attempting to compensate for these added decimating factors, more efficient management practices are being sought for the remaining breeding and wintering grounds.

In the search for better management techniques, it is essential that the role of the predator be known, and some criterion established as to what may be considered as normal predation loss.

Procedure:

Waterfowl pass through three stages; eggs, ducklings, and adults. In order to discover the degree of predation in each stage, it is necessary to utilize different methods of approach. Nesting studies reveal nest destruction and predation on nesting females. Brood counts taken regularly and accurately yield data on duckling mortality. Random

observation must be employed to a large extent in determining predation on adult birds other than nesting females. It is in interpreting data from the latter source that most caution must be exercised, as scattered records of this nature are frequently unsound bases for general conclusions.

As was explained earlier, the study area was subdivided into four smaller units; A, B, C, and D areas. In undertaking the nesting study, each of these areas was intensively searched for nests at least once a week during the nesting season. In 1953 a dog (a Labrador-Alsatian cross) was used with good success to help locate nests. The general procedure was to walk back and forth across an area, making as much noise as possible in an attempt to flush nesting birds. At the same time the ground was carefully examined for unattended, hatched, or destroyed nests. The dog would range on either side of the searcher, flushing hens or sniffing out nest locations. He became very adept at this work and on a number of occasions found nest scrapes in which eggs were not yet deposited. In 1954 the same technique was followed using two men and two dogs.

It is believed that a high percentage of nests in areas covered by the nesting study were found. This conviction is a result of the careful weekly search made with the aid of dogs, and the fact that both men and dogs daily traversed the nesting areas for one reason or another.

Brood counts were conducted on the study area and neighboring waters. The number in each brood was recorded, and the ducklings were aged as to class 1, 2, or 3. Each of these classes simply represents one-third of the period required to reach flight age. For example, if it takes 60 days for a young duck to fly subsequent to hatching, a class 1 duckling is between 1 and 20 days old, a class 2 duckling is between 21 and 40 days old, and a class 3 duckling is between 41 and 60 days old. The characters used to classify young ducks in the field are given by Blankenship et al. (1). By obtaining the difference in mean brood size between each of these classes, it is possible to secure an indication of the average loss per brood.

In aging broods, each of the three classes was divided into two subclasses--early and late class 1, class 2, and class 3. This gave a more accurate indication of age, avoided much duplication in counting, and provided a more sensitive means of tracing brood movements. Depending on the species, ducks commence flying 40 to 60 days after hatching. By conducting brood counts every 7 to 10 days one could be fairly certain that broods would have advanced in age classification to a new subclass. To illustrate, an early class 1 brood on July 1st, would be late class 1 on July 10th.

Because the size of class 1 broods undergoes a progressive decrease as the season advances (Table X) caution must be exercised in analyzing brood counts. If the smaller broods from the later part of the season are averaged with the early broods, they tend to reduce the mean size of class 1 brood data. However, since counts

terminate in the study at the end of August, many late broods fail to reach class 3 and consequently the average size of class 3 brood data is not similarly reduced. The difference between class 1 and class 3 broods will hence appear smaller than is actually the case.

In order to mitigate this error it is necessary to follow the development of groups of broods which hatch about the same time. The species in Table X spend approximately 15 days in each of the three major classes (flying 40 to 52 days after hatching), hence data for these species were treated together. The following steps were taken to trace the progress of one group of ducklings. The average of all class 1 broods counted from July 1st to July 15th was first determined; the average of all class 2 broods counted from July 16th to July 31st was next obtained; finally the average of all class 3 broods counted from August 1st to August 15th was found. The differences in brood size between subsequent classes was then computed. When this procedure is applied to each group of broods (the next group would start with all class 1 broods counted from July 16th to July 31st), a fairly accurate picture of duckling mortality is secured. As no evidence of death among young ducks through disease or inclement weather was noted, it is felt that most losses resulted from predation.

Results and Conclusions:

Predators on Study Area. Potential mammalian predators observed on the study area were skunks, coyotes, weasels, and badgers.

TABLE X

TABLE SHOWING DECREASE IN CLASS 1 BROOD SIZE
AT BI-WEEKLY INTERVALS

Species	June 1-15	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31
Pintail	6.53(17)*	5.76(29)	5.71(17)	4.00(11)		
Shoveller		8.89(9)	8.26(43)	6.80(35)	6.00(13)	
B.W.Teal			9.56(59)	7.72(106)	7.41(98)	5.89(9)
Gadwall			9.80(5)	7.80(15)	7.33(43)	7.23(10)
Baldpate			7.64(25)	7.20(16)	6.68(22)	
Scaup			8.11(9)	8.79(24)	8.32(44)	6.29(7)

* Number of broods.

TABLE XI

A SUMMARY OF THE FATES OF 332 NESTS

Year	No. Nests	% Pred. unknown	% Pred. weasel	% Pred. avian	% Pred. skunk	% Desert.	% Hatch	% Pred. total
1953	151	13.2	5.3	2.6	41.1	14.6	23.2	62.2
1954	181	12.2	1.7	2.2	30.9	20.5*	32.5	47.0

* Increased desertion reflects nest trapping activities in 1954.

Of these, skunks and coyotes were most frequently seen. Richardson ground squirrels are found locally but this species is not known to rob nests. It is also unlikely that badgers affected waterfowl here, as they were first recorded in August 1954, at which time nesting was almost completed.

Avian predators in the region were crows, gulls, and several species of hawks. Magpies, although occurring in the irrigated district five miles to the west, were unknown on the study area. This can doubtless be attributed to the lack of trees. In 1953 crows were seldom seen: the following summer, however, flocks of 10 to 70 ventured out from the irrigation areas each morning . These birds foraged around prairie potholes during the day and in the late afternoon returned to the irrigated districts to roost. California and Ringbilled gulls were also common visitors, coming chiefly from the Red Deer River five miles east.

Predation on Nests. It is often difficult to ascertain the species of predator responsible for nest destruction. Much of the indecision is attributable to the variation in so-called "characteristic sign" left by predators at destroyed nests. An excellent illustration of this situation was kindly given the writer by Robert Webb, who was recently engaged in waterfowl studies in the Brooks region. His observations on predation by gulls indicated that these birds sometimes flew from duck nests carrying eggs. On other occasions they ate them at the nest site, leaving either a neat round hole in each egg or

completely crushing it into small fragments. Comparable inconsistencies can be ascribed to other predators. In an attempt to discover predators involved in the destruction of nests, scats, tracks, and egg shell appearance were most utilized.

Table XI presents a summary of the fates of 332 nests. Two points are evident from this Table, viz., skunks are the most serious nest predators on the study area, (see Fig. 15) and the rate of predation decreased markedly in 1954.

This decrease appears largely attributable to a lessening of nest destruction by skunks. It is believed that two factors caused lower skunk predation in 1954. The first was a reduction in the skunk population. Although there is no direct quantitative proof, a series of observations tend to support this view. The number of skunks encountered dropped from eleven in 1953 to six in 1954. This occurred despite the fact that an additional man was in the field. Also, many skunk dens which were occupied in 1953 were vacant the following year.

The second factor believed to have contributed to the overall decrease in skunk predation involves new areas encompassed by the nesting study in 1954. Assistance at this time permitted an extension of the ground previously searched for nests. Many sections as far as one-half mile from water were thoroughly covered. Needless to say, nest densities here were low; however, hatching success was high. It is felt that the greater dispersion of nests resulted in lower predation.

Strong backing for the above view is found in Table XII. It

TABLE XII

A COMPARISON OF NEST FATES ON THE JUNCUS COMMUNITY AND THE SHORT GRASS PRAIRIE ASSOCIATION

Year	Veg. cover	% Pred. skunk	% Pred. other	% Desertion	% Hatch
1953	Juncus	41.3	22.7	11.3	24.7
1954	Juncus	41.7	12.5	18.0*	27.8
1953	Prairie	45.5	18.2	6.0	30.3
1954	Prairie	24.5	10.2	26.5*	38.8

* Increased desertion reflects nest trapping activities in 1954.

TABLE XIII

DUCKLING MORTALITY FROM BROOD COUNTS OF PINTAIL, SHOVELLER, BLUE-WINGED TEAL, GADWALL, BALDPATE AND SCAUP

Year	No. Broods	Ave. size class 1	Decrease in ave. size class 1 to class 2	Decrease in ave. size class 2 to class 3	Ave. loss per brood
1953	570	8.02	0.39	0.09	0.48
1954	684	7.58	0.40	0.23	0.63

must be remembered that the newly covered areas were a considerable distance from water and hence mainly on the short grass prairie association. Comparative nesting data in Table XII show that skunk predation remained almost constant on the Juncus community in 1953 and 1954, but dropped substantially on the short grass prairie association the second year.

The question next arises as to whether the hatching percentages of 23.2% and 32.5% recorded on the study area are representative. It may be argued that human scent and tracks leading to nests, predisposed them to increased mammalian predation. One way of testing this supposition is by comparing the predation rate on nests terminated before discovery, with that of nests which were still active when found. During the study, 69 terminated nests were located. (Nest data from this source have not been included in the above Tables). Of these only 15.9% had hatched. While it is admitted that some of the nests may have been deserted prior to destruction, and that hatched nests are often not as obvious as destroyed nests, the difference in hatching success is so great one must conclude that human activity had little, if any, detrimental effect on nesting success.

Predators destroyed 58% of all nests found on the study area. On the basis of investigations in other regions, this is extremely heavy predation. Kalmbach (13) compiled the results of 22 separate waterfowl nesting studies and obtained an average hatch of 60%. After desertions and accidents are considered, average predation would thus be less than 40%. Millar (18), working 100 miles N.W. of Brooks,

Fig. 15. Nest of lesser scaup destroyed by skunk.

reports 48% nest predation, less than half of which was caused by mammals.

As has been already noted, skunks were the most serious threat to duck nests. It is believed that this resulted from a large skunk population which arose in the area following development of permanent waters. It is well known that such conditions produce select habitat for this mammal. That the seriousness of predation has increased with a growing skunk population is substantiated by the findings of Turner (22). His investigations were carried out in 1948 on the same ground covered by the current study. At this time the Will J. Reid project had just been completed. Of the 49 nests which Turner found, 67.3% hatched, and total predation from all sources was only 16.3%.

Since Ducks Unlimited schemes are managed with duck production as the primary objective, it may be found advisable to undertake steps to reduce the number of skunks on this particular project.

Predation on Ducklings. Data from brood counts are summarized in Table XIII. These data indicate a loss of about 1 duckling in 14, the greatest mortality occurring among younger birds. It is very likely that both mammalian and avian predators are responsible for this loss. However, the only two depredations observed were perpetrated by hawks. In one instance a marsh hawk picked up a class 1 gadwall and in the other a rough-legged hawk caught a class 3 shoveller. It is rather interesting that ducklings exhibited no outward suggestion of fear when marsh hawks were present. Young coots and blackbirds, on the

other hand, immediately sought cover.

Predation on Adult Birds. The killing of nesting females by weasels appears to be the principal form of predation on adult birds. Female birds killed on the nest were usually found within ten feet of the nest site, Fig. 16. The only external signs of violence generally consisted of a few scattered feathers but closer examination always revealed a wound at the base of the neck. Of 332 nests 3.3% suffered weasel predation.

Coyotes and skunks occasionally capture adult ducks but this is not believed of major consequence. No conclusive records of predation by these mammals were procured during the study.

The single case of avian predation witnessed on an adult bird took place in mid-August of 1954. At this time a duck hawk knocked a female mallard to the ground, shortly after she had been flushed from cover by the dogs.

Summary:

1. Predation on nests, ducklings, and adult ducks was investigated. Nesting studies, brood counts, and direct observation were employed to assess depredations.
2. Fifty-eight percent of all nests were destroyed by predators. The greatest nest destruction was caused by skunks.

Fig. 16. Female ruddy killed by weasel: note nest on muskrat house in background with eggs undisturbed.

3. Brood count data revealed an average mortality of about 1 duckling in 14. It is felt that this loss resulted primarily from predation.
4. Weasels killed 3.3% of nesting females. This appears to be the major form of predation on adult birds.

A STUDY AND ANALYSIS OF NESTING COVER

In the past much time and effort has been expended on nesting investigations and the gathering of information as to species of plants most utilized for cover. It is seldom, however, that simultaneous studies to determine the composition of actual nesting cover, and the composition of the vegetation as a whole are conducted. Without data from each of these sources, accurate and valid appreciations of cover preference both as to species and density are impossible. In the present investigation, coincident analyses of nest cover and potential nest cover were made, thereby providing comparable data on which to base conclusions.

Procedure:

When nests were located a record was kept of the plant species providing cover. These were then classified as being of primary or secondary importance and an appraisal of nest cover was made under the classifications of poor, fair, good or very good. While it is acknowledged that human assessment of cover may vary somewhat from that of predatory birds and mammals, it is nevertheless felt that this method enables effective comparisons between nests to be carried out.

Quadrats discussed in the section on terrestrial vegetation were used to provide foundation data dealing with the quantity and composition of available cover in the various plant groups. Prior to the cutting and detailed analysis of the respective quadrats, each was

evaluated under the aforementioned headings, as to its ability to provide nesting cover. Thus if these quadrats are representative, which there is no reason to doubt, cover selection as indicated by the nesting study can be checked against availability as a means of denoting true preference from random placement.

Results and Conclusions:

The Selection of Nesting Cover. Table XIV summarizes the cover rating of 334 nests. It will be seen that there is a distinct tendency for nests to be situated in good or very good cover. In order to ascertain whether this condition was a result of deliberate selection, or merely an end product of random dispersion, it is necessary to compare the available cover as predetermined from quadrats, with the ratings of actual nests.

Table XV presents the cover rating of nests found on the short grass prairie association and the Juncus community. Below these data the potential nest cover in each plant community is also shown. It will be noted that the degree of cover recorded at actual nest sites is essentially the same in both vegetative divisions even though pronounced differences exist in the quantity of cover on these two locations. It thus seems almost certain that a deliberate selection of nesting cover is undertaken.

Strong support for the above view is found in Table XVI, where nesting densities on two adjacent pothole areas are presented. A-area was ungrazed for five years prior to the fall of 1953, while B-area was

TABLE XIV

A SUMMARY OF COVER AT 334 NESTS FOUND ON THE STUDY AREA

Year	% Very good	% Good	% Fair	% Poor
1953	22.2	56.9	15.0	5.9
1954	26.0	38.1	19.3	16.6
Ave.	24.3	46.6	17.4	11.7

TABLE XV

A COMPARISON OF NEST COVER RATINGS ON JUNCUS COMMUNITY AND SHORT GRASS PRAIRIE ASSOCIATION

Plant community		% Very good	% Good	% Fair	% Poor
Juncus	(ratings of actual nests)	20.6	56.8	17.2	5.3
Prairie		26.8	48.8	19.5	4.9
Juncus	*(potential ratings of nests on plant communities)	18.8	50.0	18.8	12.5
Prairie		4.5	9.1	40.9	45.5

* As determined from quadrats taken at the end of May, June, and July.

grazed regularly throughout this period. Consequently nesting cover on A-area was far better than that on B-area. In December 1953, cattle heavily grazed A-area; as a result its cover was much reduced. The subsequent response of ducks to this decreased cover was very pronounced. The number of nests dropped almost 50% in 1954. In B-area, meanwhile, grazing practices were unchanged and the number of nests remained the same in both years.

Differences in Degree of Concealment Sought by Species of Ducks. It has been suggested by Kalmbach (12) that tangible differences exist in the amount of concealment sought by various species of ducks when nesting. During studies on the Lower Souris Refuge in 1936 and 1937, he used a cover rating similar to the one employed in the present investigation. In tabulating and evaluating nesting cover of six common species, he tentatively assigned the values, one, two, three, and four, respectively, to the ratings of poor, fair, good, and excellent. The values obtained by the following formula were compared species with species as a measure of relative cover preference.

$$\sum \left[\frac{\text{No. nests in each class (viz., poor, fair, good, or excellent)}}{\text{Total no. of nests of the species}} \times \text{Value assigned to each class (viz., one, two, three, or four)} \right]$$

To create a common basis for comparing these data and those of the current study, the latter have been treated in a similar manner and are presented in Table XVII. Reference to this Table indicates a general relationship between species of waterfowl and the degree of nest

TABLE XVI

THE EFFECT OF GRAZING ON NEST CONCENTRATION

Location	Nests/1000 yds. shoreline 1953	1954	Nests/acre free water surface 1953	1954	Nests/acre dry land 1953	1954
A-area*	16.8	9.2	5.6	3.1	2.9	1.6
B-area**	6.5	6.5	4.4	4.4	0.8	0.8

* Cover here was greatly reduced in 1954 due to grazing the previous fall.

** Cover was the same in both years.

TABLE XVII

THE DEGREE OF NEST CONCEALMENT BY SEVEN SPECIES OF DUCKS

Species	Will J. Reid study area Alberta 1953	1954	Lower Souris Refuge* North Dakota 1936	1937
Pintail	2.44	1.85	1.85	1.83
Mallard	2.61	2.96	2.06	2.22
Shoveller	3.07	3.29	2.31	2.55
Baldpate	not sufficient data		2.31	2.64
Gadwall	3.20	3.14	2.50	2.77
B. W. Teal	3.18	3.14	2.56	3.01
Scaup	3.25	3.33	no data presented	

* From Ref. (12)

cover which was much the same in both studies. The quantitative variations between the data of each can doubtless be attributed to either a difference in available cover or the subjectivity of cover appraisals at the nest site. In both investigations, pintails and mallards exhibited the least preference for better nesting cover. An excellent example of this apparent indifference was manifested by pintails which nested in 1954 on a section of prairie accidentally burned during April of this same year. Concealment here was nil, yet these birds ignored this situation and nested despite it (Fig. 17). Never was the expression, de gustibus non est disputandum, more applicable.

Preferences for Particular Plant Species as Nesting Cover. The next point to consider is whether preferences for specific plants are exhibited by waterfowl selecting nest locations. Girard (9) working in Montana found over 78% of shoveller nests in grass, but failed to state the frequency of occurrence or relative abundance of species involved. Stipa viridula and Agropyron Smithii were found by Bue et al. (2) to provide primary cover for the majority of nests around artificial impoundments in South Dakota. Williams and Marshall (24) report preference for Scirpus acutus, Salix spp., Phragmites communis, Hordeum jubatum, Carex spp., and weeds, in the Bear River Refuge, Utah.

As previously discussed, three main groups of terrestrial plants are recognized on the study area, while the principal emergent

Fig. 17. Nest of pintail on burned short grass prairie association May 18, 1954. Nothing has been altered at the nest site.

cover consists of cattail interspersed with limited stands of planted roundstem bulrush. Table XVIII briefly outlines the nesting density within each. One must be cautious in interpreting the final column of this Table, particularly nest densities in emergent cover. It is important to realize that due to grazing, cattail growth is restricted to island peripheries and the fenced area. Because of this limited distribution, the emergent nesting species, redheads, canvasbacks, and ruddy ducks, were forced to concentrate here. This resulted in a relatively high nest density. It would thus be erroneous to make an unqualified comparison of nest densities in emergent cover with the other vegetative types.

Referring to the non-emergent cover in the Table; the Juncus community supported a nest concentration four and one half times as great as the short grass prairie association. It is believed erroneous, however, to attribute this difference to a preference for specific plants. Table XV revealed that the quantity of good and very good cover in the Juncus community is five times greater than in the short grass prairie association (see Fig. 18 and Fig. 19), hence the increased nest density may be simply a response to better cover. Unfortunately sufficient data are not present to test this hypothesis on the Hordeum community.

By comparing the number of times a species constituted the primary source of nest cover, with the number of times it formed the primary cover in quadrats, some indication may be obtained as to whether a deliberate selection of certain plants occurs. Table XIX

TABLE XVIII

THE RELATIVE AREAS OF VARIOUS COVER TYPES AND THE NEST DENSITY IN EACH

Cover type	% Acreage	% Nests	Acres/nest
Cattail and Scirpus	1.9	12.3	0.35
Juncus community	30.0	59.4	1.23
Short grass prairie assoc.	59.5	26.1	5.57
Hordeum community	8.6	2.2	9.60

Fig. 18. Typical nesting cover on the Juncus community.

Fig. 19. Typical nesting cover on the short grass prairie association. The tall grass is Calamovilfa longifolia which is unpalatable to livestock.

TABLE XIX

A COMPARISON OF PRIMARY NEST AND QUADRATE COVER IN THE PRAIRIE ASSOCIATION

Species	% Primary cover over nests	% Primary cover in quadrats*
Calamovilfa longifolia	52.4	40.0
Thermopsis rhombifolia	13.4	
Rosa spp.	8.5	
Agropyron Smithii	7.3	
Artemesia spp.	3.7	
Stipa comata and Koeleria cristata**	3.7	33.3
Carex spp.	3.7	13.3
Bouteloua gracilis	1.2	13.3
Miscellaneous spp.	6.1	

* From quadrats taken at the end of May, June, and July. It was arbitrarily decided that only species whose average height was greater than 6" in the quadrat would be considered as potential nest cover.

** Frequently vegetatively undistinguishable, hence grouped together.

presents a summary of such data from the short grass prairie association. It is interesting to note that Stipa comata, Koeleria cristata, Carex spp., and Bouteloua gracilis, which comprised 60% of the potential primary nest cover in the quadrats, composed only 8.6% of the primary cover at actual nests. Thermopsis rhombifolia, Rosa spp., Agropyron Smithii, Artemesia spp., and miscellaneous species constituted the principal cover for 39% of the nests but in no instance did these appear as the primary source of cover in the quadrats. Calamovilfa longifolia was the major cover species at 52.4% of the nests, and in 40.0% of the quadrats. One final observation should be made from this Table; those plants contributing the largest percentage of nesting cover are by and large unpalatable to livestock.

Effect of Grazing on Nesting Cover. The influence of livestock on nesting cover is of interest as the study area is situated on a community pasture. A comparison of the cover rating of grazed and ungrazed quadrats in the short grass prairie association and the Juncus community is given in Table XX. Unlike Tables XV and XIX, Table XX includes data from the August quadrats. These were omitted previously when a comparison of actual and potential nesting cover was made, since few nests are initiated in August and cover during this month is not subject to selection. There is good reason for incorporating August quadrat data in Table XX, however, as grazing at this time has a direct bearing on the amount of cover available the following spring. Grazing is shown to have the most

TABLE XX

A COMPARISON OF COVER RATING OF GRAZED AND UNGRAZED QUADRATS*

Plant group	Condition	% Very good	% Good	% Fair	% Poor
Short grass	ungrazed	16.7	41.7	8.3	33.3
prairie assoc.	grazed	0.0	8.3	75.0	16.7
Juncus	ungrazed	33.3	33.3	16.7	16.7
community	grazed	33.3	50.0	16.7	0.0

* Quadrats taken at the end of May, June, July and August.

pronounced effects on cover in the short grass prairie association. This of course was anticipated in view of the relative unpalatability of Juncus balticus. Ungrazed prairie association had 58.4% good and very good cover, while only 8.3% of that on grazed prairie could be similarly classified. This represents a reduction to one seventh in the the best classes of nesting cover. There is likely no significance in the increased good cover on grazed quadrats of the Juncus community.

Effect of Cover on Nest Predation. The effect of nest cover on the rate of predation is at present a point of much controversy. A search of the literature discloses differences in findings and opinion on this topic. For example; a study (11) conducted in Saskatchewan revealed that nests with the least cover had the greatest hatching success. The same investigator working in South Dakota two years later (12) reports the highest percentage hatch in excellent cover, and the lowest in poor cover. An analysis of data from the current research is contained in Table XXI. In order to present an unbiased description of the relationship, if any, between cover and predation, nest failures due to desertion or additional factors other than predation, have been deleted from this Table. In referring to these data, there is no evidence that increased cover raises the percentage hatch. In fact there is a suggestion that nests in poorer cover suffer less predation.

Utilization of Old and New Cover. To conclude this discussion on nesting cover, an analysis of the respective contributions of old

TABLE XXI

THE EFFECT OF COVER ON NESTING SUCCESS

	Very good	Good	Fair	Poor
% Hatch	37.5	30.6	41.2	40.6

TABLE XXII

THE UTILIZATION OF OLD AND NEW GROWTH IN NESTING COVER

Type of cover	Old	Old and new*	New and old**	New
% Utilization	41.6	18.1	7.8	32.5

* Mainly old growth.
** Mainly new growth.

and new plant growth is given in Table XXII. It is not surprising that old growth makes the greatest contribution, for nesting commences in late April. This is at least a month before the earliest spring growth attains heights capable of providing nest cover. The importance of old or new cover to any one species of duck is naturally dependent on its nesting period. Pintail nest cover consisted of 73% old, 15% new, and 12% mixed. The later nesting scaups utilized 78% new growth, 22% mixed, and on no occasion were dependent exclusively on the previous year's vegetation for cover.

Summary:

1. An integration of data from the nesting and vegetative studies was conducted in an attempt to discover factors involved in the choice of nesting cover, and their influence on nesting success.
2. The following conclusions were reached:
    a. There is a definite selection of the better classes of cover for nesting sites.
    b. The relative amount of concealment sought by different species of ducks on the study area is comparable to that reported in other investigations. Pintails are least desirous of nesting cover.
    c. Stipa, Koeleria, Carex, and Bouteloua contributed 60% of the potential nest cover in quadrats, but at actual nest sites constituted less than 9%

of the principal cover. Thermopsis, Rosa, Agropyron, Artemesia and miscellaneous species were the chief cover at 39% of the nests, yet at no time did they appear so in quadrats.

d. Grazing resulted in a marked reduction in nesting cover on the prairie association, but had no apparent effect on the Juncus community.

e. Old growth was used exclusively as cover at 41.6% of the nests, while new growth was used exclusively at 32.5%.

f. No correlation was found between nest concealment and predation.

POPULATION MOVEMENTS

If waterfowl breeding grounds are to be efficiently developed and managed, a knowledge of preferred habitats is of the utmost importance. Information of this nature can be extremely useful to such organizations as Ducks Unlimited. When constructing "duck factories", Ducks Unlimited frequently have considerable control over the size, shape, and depth of impoundments, and the shoreline and nesting cover which later develops. Since waterfowl response to various habitat types differs, planning and management of these schemes must be based on known duck behaviour if maximum production is to be realized.

One of the objectives of the current study was to determine the utilization of different waters by adults and broods. On the study area it was possible to contrast and compare the usage of:-

(A) potholes with either Juncus-Carex or cattail shorelines;

(B) small lakes with either Juncus-Carex or mud shorelines;

(C) and small lakes with potholes.

Procedure:

Regular counts of adult birds were made on A, B, C, and D areas. In 1953 these were initiated on May 22nd and in 1954 on May 4th. The number of counts was increased from 15 in 1953 to 50 in 1954, hence the latter year's population curves are smoother and probably more accurate. Rules governing the counting procedure were as follows:

1. All adult ducks on an impoundment or its immediate shoreline were counted, except females with broods.
2. Birds were classified as to species and sex.
3. All counts were conducted in the morning between 8 a.m. and 12 a.m.
4. The same route was traversed each time. The nature of this route was such that the chance of scaring ducks from one area to another was minimized.

Adult counts ceased in mid-July of both years. Counts subsequent to this date are impractical because:

1. Many males are well into eclipse plumage and hence practically indistinguishable from females.
2. Large numbers of post-breeding drakes have left for bigger lakes on which they pass the flightless phase of their moult.
3. It is almost impossible to differentiate between late class 3 ducklings and adult birds.

Brood counts were also undertaken as outlined in the section on predation, and are used in the present discussion as a means of tracing brood movement.

Results and Conclusions:

Adult Population Movements. Figs. 20 and 21 show the adult duck population on A and B area potholes. On the basis of these data, the over-all population was much the same on both types of potholes. It is likely that the normal curve for such areas is a low bell graph, skewed somewhat to the left. It is thought that the early peak of this curve represents a fairly rapid build up of breeding birds on territory. Its gradual decline may be ascribed to the progressively overlapping nesting dates of different species and to renesting. That the average curve for these pothole areas is largely attributable to breeding birds, is in part substantiated by the high nest densities occurring here.

Adult populations on D-area lake are plotted in Fig. 22. Numbers were high in early May of 1954, dropped rapidly until mid-May, became stabilized, then gradually fell until counts ceased. Available data from 1953 (mid-May to mid-July) suggest a trend similar to that revealed by data obtained during the same period in 1954.

There appear to be two factors responsible for the large initial population. First, extensive numbers of ruddies, green-winged teal, canvasbacks, and redheads were present here in early May. These birds soon departed, however, together with such species as red-breasted mergansers, American golden-eyes, and whistling swans, and it is suspected that they too were merely migrants. Secondly, substantial numbers of pintails also frequented this lake in early May. As far more pairs were observed than were later shown to nest in the

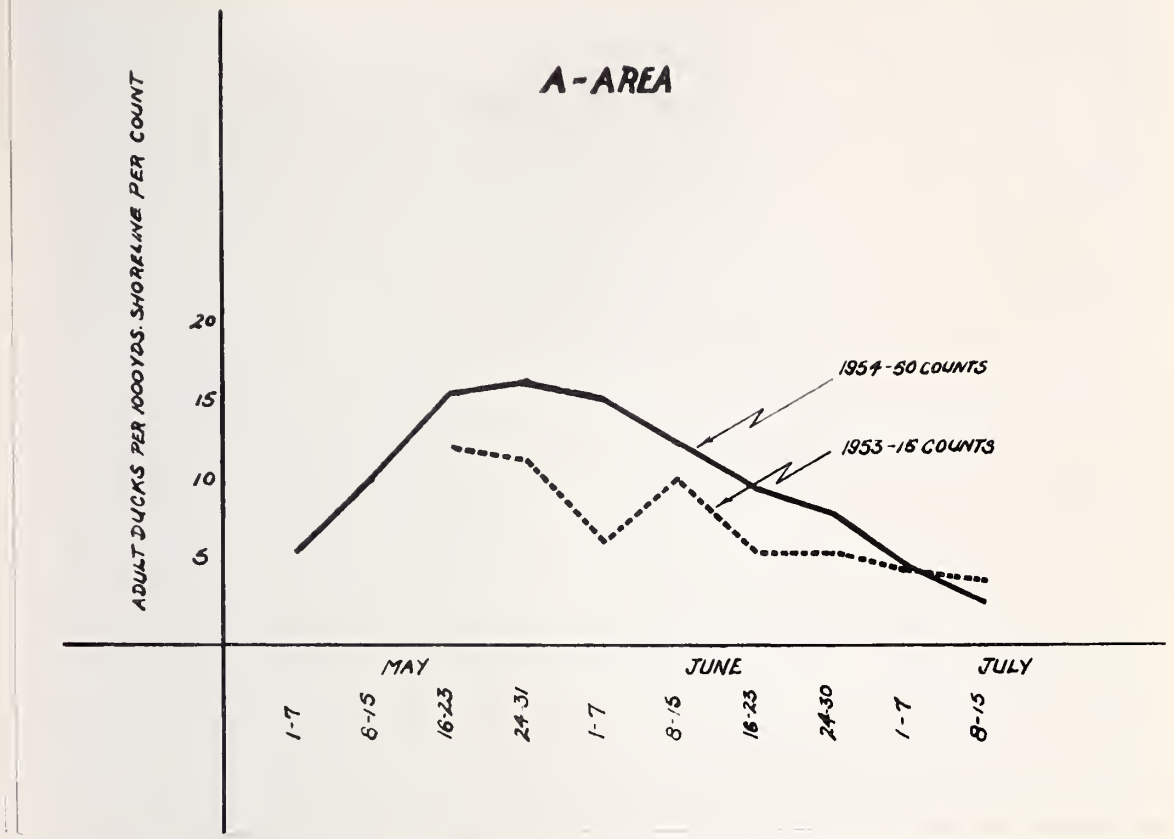

Fig. 20. Adult duck populations on A-area potholes.

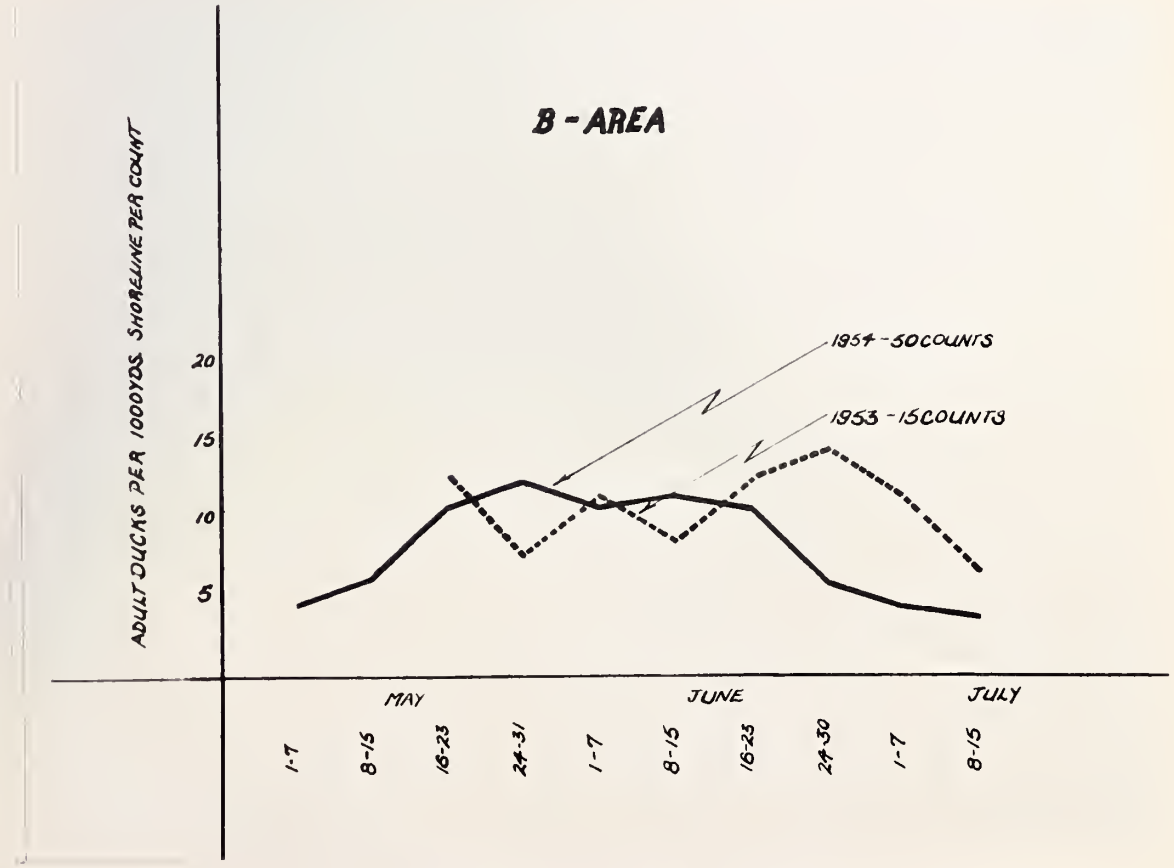

Fig. 21. Adult duck populations on B-area potholes.

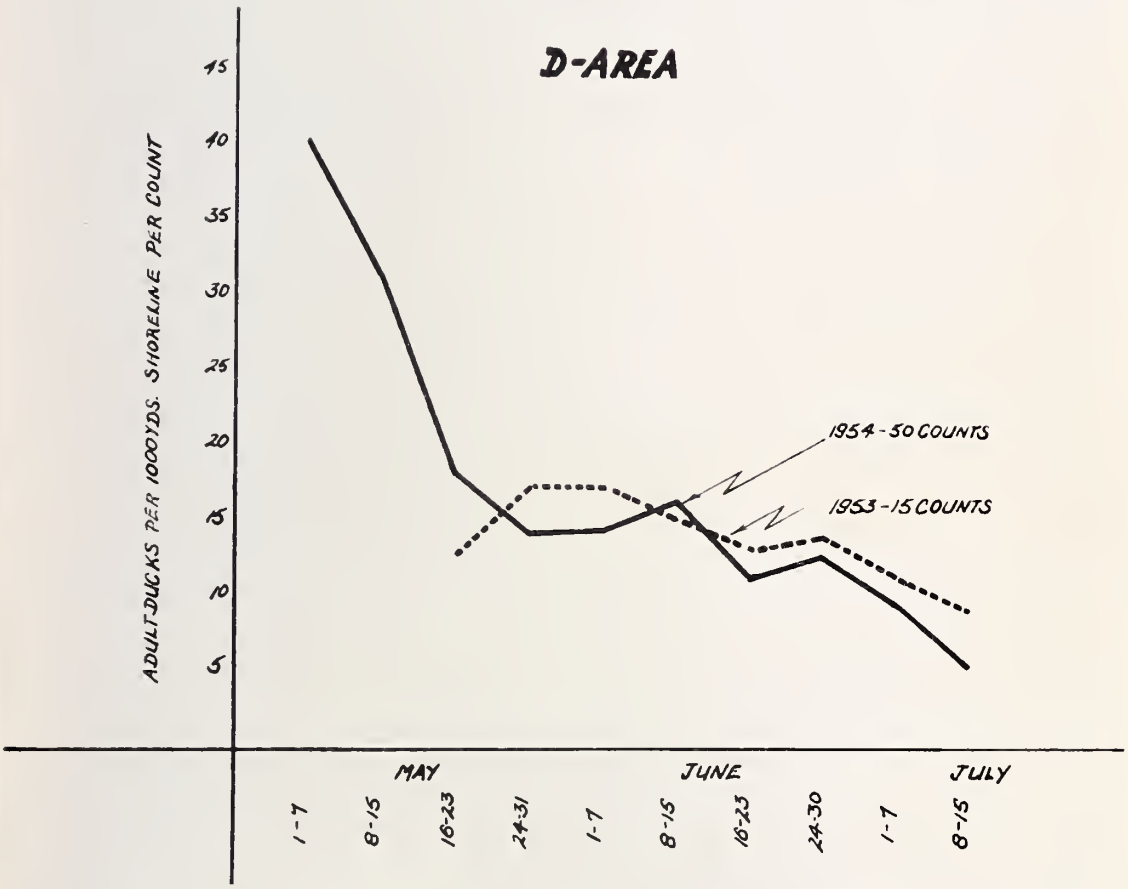

Fig. 22. Adult duck populations on D-area lake.

immediate area, these were quite likely local birds as yet undispersed for nesting.

The last three-quarters of this curve is similar to that of pothole areas and probably reflects the behaviour of the lake's breeding population.

Fig. 23 represents the population curves for C-area, which in 1953 constituted two small lakes with extensive mud-flats and mud shorelines. In 1954 only one lake was still in this condition. As a result the 1953 population curve consists of data from both lakes (C_y and C_z), while the following year's curve is based entirely on counts from C_y.

On the mud-flat areas, duck numbers remain fairly stable until June, at which time the population rapidly doubles or triples. By mid-July, however, numbers have fallen again to early season levels. There appears to be a fairly simple explanation for this curve. Although not unduly attractive as territorial waters, these areas are favoured loafing and resting places. Hence, in early June the breeding population is supplemented by large flocks of post-breeding drakes. Freed of their nuptial duties, these males concentrate on the mud bars to loaf and rest. Mallards and pintails first appear, followed by shovellers, baldpates, gadwalls, etc.. As the flightless stage of the annual moult approaches, they leave the study area causing the adult population of mud-flat areas to drop accordingly. Most of these drakes pass the flightless period on certain large lakes in the district.

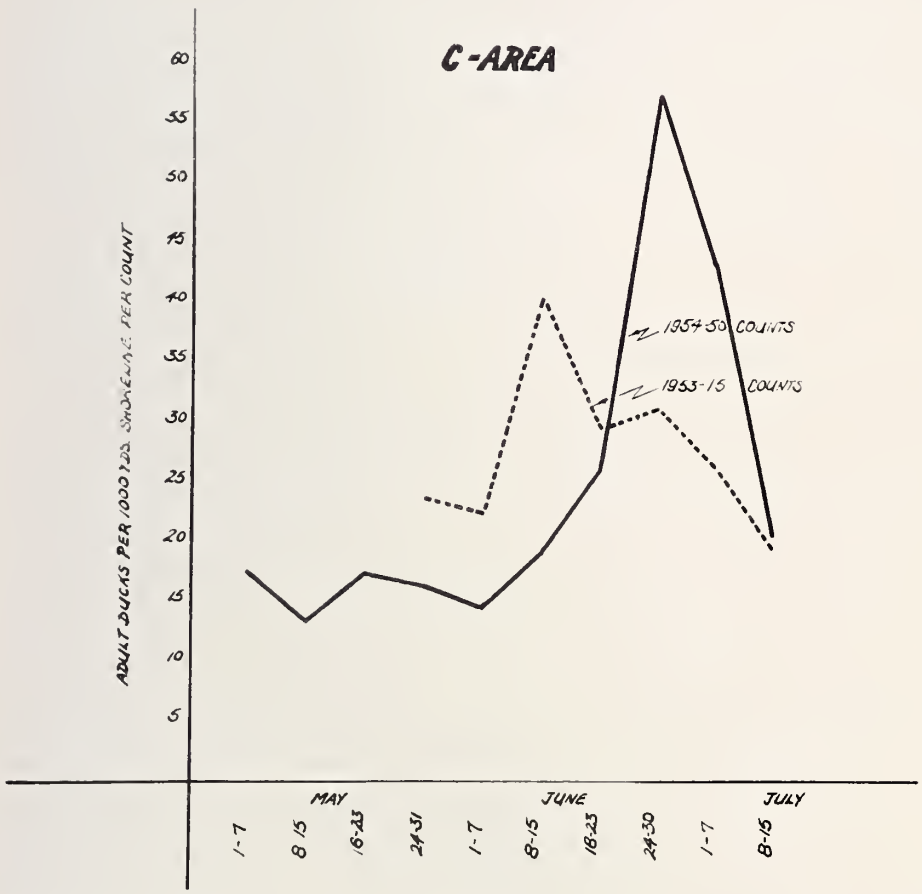

Fig. 23. Adult duck populations on C-area lakes.

Species Composition and Preferences. Table XXIII summarizes species composition of adult duck populations on the study area. The three principal species of ducks were scaup, blue-winged teal, and pintails which composed over 50% of the population between mid-May and mid-July.

This Table also reveals several strong indications of species preference for particular habitat types:

1. Blue-winged teal displayed a definite preference for pothole areas, utilizing them almost twice as much as the small lakes.
2. White-winged scoters preferred the mud-flat areas and on no occasion were recorded elsewhere.
3. Areas with emergent cover (A and D areas) are most attractive to ruddies and redheads.

Brood Movement. Over-all trends in brood movement were investigated and are presented graphically in Figs. 24 and 25. As was explained earlier, broods were classified as early or late class 1, 2, and 3 according to their estimated age. Thus each brood passed through six subclasses from hatching until flight. Duplicate counts of one brood with a single subclass were avoided by adequately spacing counting dates and by back-checking brood records on individual waters. The latter method was most frequently employed on the study area where constant and intimate contact permitted an enumeration of a high percentage of broods.

In Figs. 24 and 25 the number of brood subclasses on waters of the study area is presented. To facilitate graphing and to achieve a smoother curve, bi-monthly totals are plotted. The results are essentially the same for both years, except that peak brood populations occurred later in 1953 than in 1954. This situation reflects the late and extended hatching period of the former year, a condition which was common across most of the prairies.

Data indicate that broods tend to move from the smaller to the larger impoundments. Evidence of this comes from the earlier peak in brood numbers on A-area potholes, and the relatively lower number of broods on potholes as compared to lakes. (Broods of B-area were too few to allow graphing). These circumstances prevailed despite the fact that nesting was most concentrated in the pothole areas. The only plausible explanation seems to be that larger waters provide increased security against drought, and a greater field of observation. This latter factor may be of considerable importance as it is usually much more difficult to stalk broods on lakes than on potholes.

It is also interesting to note the tremendous increase in brood usage of C_Z area in 1954. It will be remembered that in 1953 this lake had mud shorelines. However, the following year, as a result of raising its water level, shorelines consisted of flooded Hordeum and Juncus community species. These provided excellent brood cover and an abundance of readily accessible food. Response to such ideal habitat was rapid and dramatic as witnessed in Fig. 25.

TABLE XXIII

SPECIES COMPOSITION OF ADULT DUCKS ON THE STUDY AREA
MID-MAY TO MID-JULY

	1953					1954				
Species	% on A area	% on B area	% on C area	% on D area	% Total	% on A area	% on B area	% on C area	% on D area	% Total
Scaup	25.6	16.9	28.9	41.7	31.0	17.1	20.5	9.1	34.8	18.8
B.W.Teal	29.8	42.1	14.3	19.2	18.0	34.3	31.1	18.3	22.6	25.4
Pintail	2.7	4.1	17.2	4.3	10.7	7.2	14.8	15.4	7.2	10.8
Baldpate	2.7	5.0	8.9	4.7	6.7	2.9	8.8	9.5	4.2	6.1
Mallard	9.2	5.5	5.1	3.7	5.9	5.0	4.4	4.1	3.2	4.5
Ruddy	15.7	.	1.4	7.0	5.4	9.3		0.5	2.1	3.6
Redhead	7.1	1.6	4.6	5.8	5.2	7.3		3.8	5.8	5.0
Shoveller	4.4	8.9	3.7	5.0	4.8	8.0	9.9	7.8	5.6	7.5
Gadwall	1.8	2.6	4.8	4.3	4.0	4.9	7.1	11.7	8.4	8.3
G.W.Teal	1.0	13.3	2.9	2.4	3.7	3.0	3.4	2.7	1.1	2.5
W.W.Scoter			7.3		3.7			3.9		1.4
Canvasback			0.6		0.3	1.0		0.6	3.9	1.4
Others			0.3	1.9	0.6			0.6	1.1	0.5
Unidentified*								12.0		4.2

* Chiefly pintail, baldpate and mallard drakes which arose from C-area in large flocks during counts making accurate identification as to species impossible.

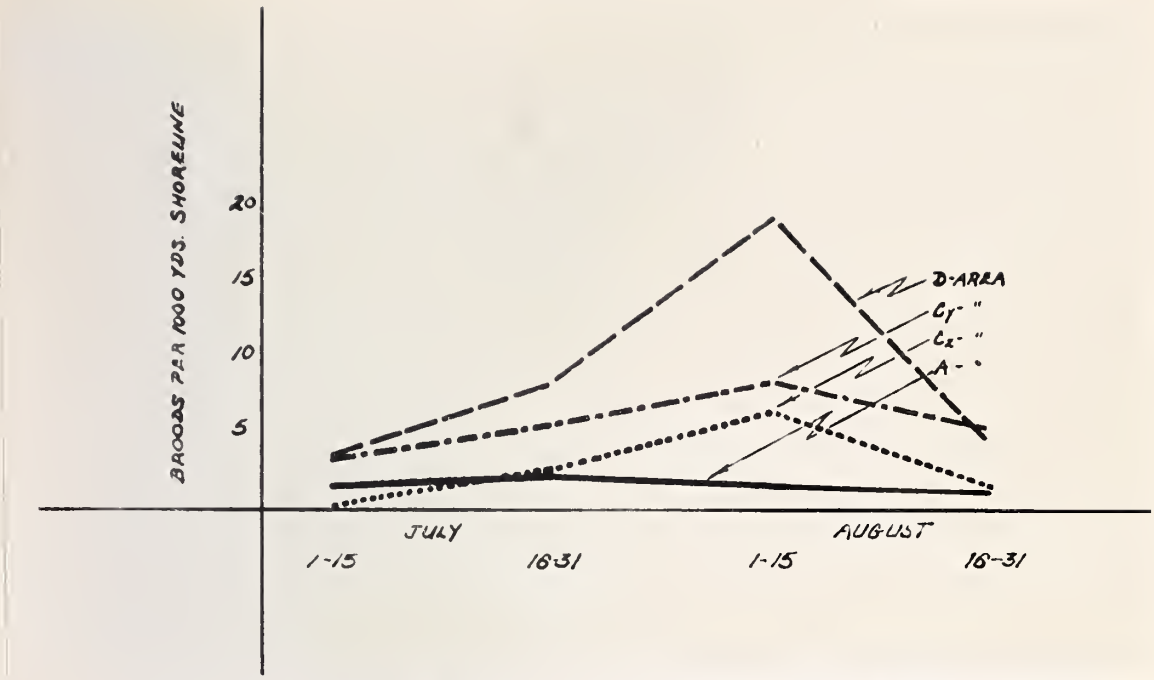

Fig. 24. Brood populations on A, C_y, C_z, and D area waters - 1953.

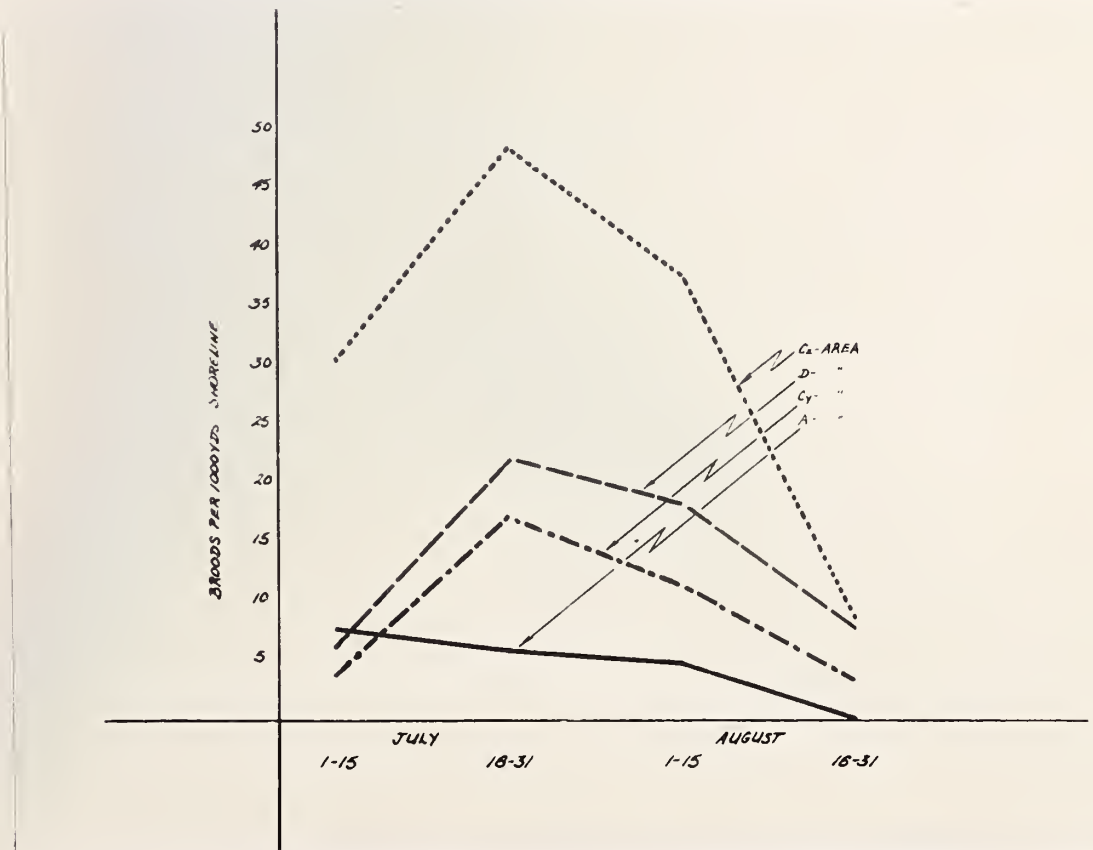

Fig. 25. Brood populations on A, C_y, Cz, and D area waters - 1954.

Summary:

1. Duck counts were conducted on A, B, C, and D areas in order to determine utilization by adult birds.
2. Seasonal population trends on both pothole areas were found to be similar, likely as a result of usage by breeding birds. Large concentrations of post-breeding drakes frequented C-area's mudflats in early June, resulting in an entirely different population curve. D-area was used extensively in early May by migrating waterfowl, and large numbers of paired pintails. These combined to produce still another type of population curve.
3. Scaup, blue-winged teal, and pintails were the principal species on the study area, constituting over 50% of the adult population.
4. Preferences were displayed by blue-winged teal, white-winged scoters, ruddies, and redheads for particular types of impoundments.
5. Brood counts indicate a definite movement from the pot-holes to the lakes, viz., from the smaller to the larger waters.
6. In 1954 broods displayed a marked preference for C_Z, a small lake whose water level had been raised and whose shoreline as a result consisted of flooded vegetation.

STOMACH ANALYSES

There have been few food habit studies conducted on the Canadian prairies. The chief works are the U. S. Dept. Agr. publications, "Food of Game Ducks in the United States and Canada" (14), and "Food of North American Diving Ducks" (8). It is only in the latter publication that statistics are presented on analyses of juvenile stomachs, and these are of course all diving species. A check on the sources of stomachs analyzed from the "Western Canadian Region" (14), reveals that less than 10% were from typical prairie regions. The vast majority were collected in the mountains and parklands. Hence, quantitative knowledge of plant species most frequently eaten by ducks on the short grass prairie is practically non-existent.

Procedure:

A number of stomachs from both adults and young were obtained on or near the study area. These were acquired during each of the four months spent in the field yearly. Table XXIV outlines the ages and species composition of this sample. While some birds were deliberately collected for stomach analyses, as many more were victims of predation or died from unknown causes.

Detailed analyses were made during the winter at the University of Alberta. The laboratory technique was evolved from procedures discussed by Cottam (7) and Martin (17).

Stomach contents were preserved in formalin prior to examination. The first step in analysis was a separation of gravel from organic

TABLE XXIV

COMPOSITION OF THE SAMPLE USED FOR STOMACH ANALYSES

Species	Adults	Class 3 Ducklings	Class 2 Ducklings	Class 1 Ducklings	Total
Pintail	7	11	4	9	31
Mallard	4	11	3	1	19
Gadwall	6		1		7
B.W.Teal	2		2	2	6
Baldpate	3	3			6
G.W.Teal	4				4
Shoveller	3	1			4
Scaup	2				2
Canvasback	1				1
Ruddy	1				1
Total	33	26	10	12	81

matter. This was accomplished by decanting the lighter organic components and trapping them on filter paper. A separation of seeds from other organic material was next carried out. If the numbers of seeds were relatively small, these were extracted with forceps; if the numbers of seeds were relatively large, the finer organic matter was carefully decanted and forceps were used to remove the coarser pieces. The seeds were then examined, segregated, and classified as to species.

Gravel, seeds, and organic material, were air dried and the quantity of each measured volumetrically. It was found that a centrifuge was useful at this time, particularly in determining the volume of miscellaneous organic matter. Much of this was colloidal in nature and centrifuging quickly settled the dispersion and enabled readings to be made swiftly and accurately. When the quantity of seeds was sufficient, the volume of each species was measured. If only a few were present these were counted and their volume computed by multiplication with a constant. This constant was predetermined for each species by securing the volume of known numbers of seeds. No attempt was made to separate or identify food of animal origin. Percentage utilization of the various seeds was computed on the basis of total organic matter, exclusive of gravel.

Results and Conclusions:

Food Habits of Adults and Ducklings. The results of analyses are found in Table XXV. From these data several conclusions may be drawn:

TABLE XXV

VOLUMETRIC ANALYSIS OF STOMACH CONTENTS SHOWING PERCENTAGE SEEDS PRESENT

Plant species	Adults		Ducklings	
	% Volume	% Occurrence	% Volume	% Occurrence
Eleocharis	2.53	11.71	11.96	15.90
Carex	1.14	23.43	8.07	24.09
Myriophyllum	7.03	13.51	4.70	13.03
Potamogeton	8.50	18.02	3.10	16.62
Polygonum	0.49	7.12	2.11	3.15
Scirpus	5.47	8.11	2.07	5.79
Ranunculus	0.01	2.70	1.55	4.04
Juncus	16.42	6.31	1.17	6.10
Alisma	0.11	0.90	0.54	1.91
Distichlis			0.52	0.30
Hippuris			0.33	4.88
Hordeum	0.11	3.60	0.13	0.60
All other organic matter	58.19		63.75	

1. Seeds of Eleocharis and Carex were most important to ducklings and comprised 20.03% of the food consumed. Species of greatest importance to adult ducks were Juncus and Potamogeton whose seeds constituted 24.73% of the organic matter in stomachs.
2. Myriophyllum is the third most utilized species by both adults and young.
3. Seeds of Scirpus are chiefly consumed by adult ducks, while those of Polygonum and Ranunculus are most frequently eaten by ducklings.

Since all species shown to be of major consequence as duck food, are abundant in the region, it is quite likely that the above distinctions are valid exhibitions of preference.

Seed size may have some bearing on the food habits of ducklings. Carex and Eleocharis seeds, for example, are less than one-half as large as Juncus (capsules), and about one-fifth as large as those of Potamogeton. Apropos of Table XXV, note the high correlation between the columns listing percentage occurrence of various seeds in the stomachs of ducklings and adults. It is difficult to suggest a reasonable explanation for this in view of the fact that there is little relationship between the columns listing volumes of seeds eaten.

In Table XXVI the quantity of seeds consumed is compared with consumption of other organic matter. The only pronounced difference in the ratio of seeds as shown in this Table to other organic

TABLE XXVI

THE CONSUMPTION OF SEEDS AS COMPARED WITH OTHER ORGANIC MATTER

Food	Adults	Ducklings		
		Class 3	Class 2	Class 1
% Seeds	42.08	50.94	44.21	13.73
% All other organic matter	57.92	49.06	55.79	86.27

matter, occurs with class 1 ducklings. It would appear from these data that once passed this stage, young ducks eat the same relative quantity of seeds as adults.

Summary:

1. Analyses were conducted on the stomachs of 33 adults and 48 ducklings collected in or near the study area.
2. Seeds of Eleocharis and Carex were most important to ducklings, while those of Juncus and Potamogeton were of greatest importance to adult ducks.
3. The relative quantity of seeds in stomachs of class 1 ducklings was much less than in other classes of ducklings or adult birds. Young ducks other than class 1 consumed the same relative quantity of seeds as adults.

REVIEW

Past waterfowl studies have usually been restricted to investigation and analysis of one particular aspect of preference, behaviour, etc. Little effort has been made to integrate data from a series of concurrent studies involving many phases of waterfowl ecology. Although the present study makes no claim of being all-embracing, it is nevertheless felt that sufficient data were collected to permit the formulation of certain ecological concepts. Such knowledge is frequently of far greater importance to the wildlife manager than the intricate details of a single mechanism. As a summary is presented at the end of each section, it is merely proposed at this point to review briefly those findings applicable not only to the study area, but quite likely to most similar sites on the short grass prairie.

Nesting Cover:

Nesting cover is subject to definite selection by waterfowl. Vegetative analyses of the two principal plant communities on the study area, viz., the short grass prairie association and the *Juncus* community, disclosed pronounced differences in the quality of potential nesting cover. Despite this situation, the cover rating of nests found in each of these plant communities was essentially the same. There are also definite indications that nest cover selection may involve preference for certain plants.

Kalmbach (12) suggested that the degree of nest concealment

sought by ducks varies between species. Data presented by him were largely corroborated by the current study. Particularly impressive was the apparent disregard of pintails for nesting cover.

Population Movements:

From adult duck counts and brood counts conducted on the study area, several generalizations as to population shifts seem permissible.

Most waterfowl activity in early May is centered on or around the larger impoundments. Populations here soon drop, however, as migrants pass on, and local birds disperse to pothole areas. These provide attractive territorial waters and are favoured nesting sites. As the sexual cycle in males wanes, mate and territory are abandoned and large concentrations of post-breeding drakes are then seen loafing and resting on mudflat areas.

Brood movement likewise exhibits specific trends. In particular there is a tendency for broods to move from the smaller to the larger waters, i.e., from potholes to lakes.

Predation:

Predation is an omnipresent menace to all wildfowl populations. So diverse is its nature however, that broad generalizations are dangerous and often impossible. In order to correctly assess the significance of local predation, it is necessary to compare it with that on other waterfowl breeding grounds.

On the study area, as elsewhere, greatest losses occur through nest predation. Its incidence here is considerably higher than reported

in other studies, and waterfowl production is doubtless being seriously affected. Since this area is fairly representative of other Ducks Unlimited projects in the region, it is reasonable to assume that similar losses are occurring there also.

Although few nests were destroyed by crows, it is believed that this form of predation will become increasingly important. The establishment of permanent waters has spurred plant succession to tree growth and is rapidly producing an environment attractive to crows. Fortunately grazing holds this succession in check, thus restricting the problem largely to fenced areas.

Effect of Grazing:

Grazing is the most common agricultural impingement on waterfowl habitat throughout the prairies, and one which is frequently capable of some regulation and management. For this reason it is essential that the effects of grazing be thoroughly understood.

Of the three terrestrial plant communities recognized in the study area, only on the short grass prairie association was grazing found to reduce nesting cover. Hence it is here that fencing programs to improve cover will be most practical.

The value of fencing cannot be judged solely on the resulting increase in nesting cover, as other factors may enter the picture. It has been noted that cattail rapidly becomes established on ungrazed shorelines, and where waters are shallow this emergent may monopolize large areas. Brief mention was also made of willow and poplar stands

in fenced areas, and their future attraction to such nest predators as crows and magpies.

Soil Changes:

The evolution of certain neutral non-saline soils on the study area to saline or saline-alkaline states is particularly significant, for should this trend continue, vast changes in the vegetative cover are destined to occur.

Although the effect of this plant succession on waterfowl is at present largely speculative, indications are that it would be very detrimental.

ACKNOWLEDGMENTS

I am deeply indebted and sincerely grateful to Professor Wm. Rowan who suggested and supervised this study. Our many pleasant hours together have been an inspiring experience and will long be remembered.

Financial support from the following organizations is gratefully acknowledged: The R. Howard Webster Foundation of Montreal, The National Research Council of Canada, The Agricultural Institute of Canada, and Ducks Unlimited (Can.)

I wish in addition to express my appreciation to Dr. E. H. Moss, for assistance in botanical problems, and to Dr. W. Corns for advice on the herbicide experiment. The field assistance and cheerful companionship of Mr. Bill Wishart was also of great help. To the management and staff of Ducks Unlimited, particularly Messrs. William Campbell and Martin Jolitz of Brooks, I offer my thanks for their generous co-operation.

To conclude, it is particularly pleasant to acknowledge the contribution of my wife who typed the manuscript, and whose interest and encouragement have meant a great deal.

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APPENDIX

PLANTS OF THE STUDY AREA

PLANTS OF THE SHORT GRASS PRAIRIE ASSOCIATION

Major	Common	Occasional
	Family - EQUISETACEAE	
	Equisetum kansanum	
	Family - GRAMINEAE	
Agropyron Smithii	Agropyron subsecundum	Agropyron dasytachyum
Bouteloua gracilis	A. trachycaulum	Elymus canadensis
Calamovilfa longifolia	Agrostis scabra	Oryzopsis hymenoides
Koeleria cristata	Calamogrostis montanensis	
Stipa comata	Poa arida	Poa pratensis
	P. Canbyi	Stipa viridula
	P. secunda	
	Spartina gracilis	
	Family - CYPERACEAE	
Carex Douglasii		
C. eleocharis		
C. heliophila		
	Family - LILIACEAE	
	Allium textile	
	Zygadenus gramineus	
	Family - IRIDACEAE	
	Sisyrinchium angustifolium	
	Family - CHENOPODIACEAE	
	Salsola pestifer	
	Family - NYCTAGINACEAE	
		Oxybaphus hirsutus

Major	Common	Occasional
	Family - PRIMULACEAE	
		Dodecatheon pauciflorum
	Family - RANUNCULACEAE	
	Ranunculus glaberrimus	Pulsatilla ludoviciana
	Family - CACTACEAE	
	Mamillaria vivipara	Opuntia sp.
	Family - ONAGRACEAE	
	Epilobium adenocladon Gaura coccinea Oenothera Nuttallii	Epilobium angustifolium Oenothera biennis
	Family - CARYOPHYLLACEAE	
	Cerastium arvense	
	Family - MALVACEAE	
		Malvastrum coccineum
	Family - LEGUMINOSAE	
Thermopsis rhombifolia Vicia trifida	Astragalus caryocarpus A. triphyllus Glycyrrhiza lepidota Petalostemon purpureus	
	Family - VIOLACEAE	
	Viola adunca V. vallicola	

Major	Common	Occasional
	Family - ROSACEAE	
	Potentilla arguta	Geum triflorum
	Rosa arkansana	
	Family - CRUCIFERAE	
	Arabis Holbellii	Descurainia Sophia
	Erysimum parviflorum	
	Lepidium densiflorum	
	Lesquerella arenosa	
	Family - COMPOSITAE	
Artemesia frigida	Antennaria microphylla	Achillea lanulosa
A. gnaphalodes	Artemesia caudata	Artemesia pabularis
	Aster ericoides	Crepis tectorum
	Chrysopsis villosa	Erigeron philadelphicus
	Cirsium undulatum	Lactuca pulchella
	Erigeron canadensis	Senecio palustris
	Grindelia perennis	Taraxacum officinale
	Gutierrezia diversifolia	
	Liatris punctata	
	Lygodesmia juncea	
	Ratibida columnifera	
	Rudbeckia hirta	
	Solidago spp.	
	Tragopogon dubius	
	Family - POLEMONIACEAE	
	Phlox Hoodii	
	Family - SCROPHULARIACEAE	
	Pentstemon gracilis	Orthocarpus luteus
	P. procerus	
	Family - CAMPANULACEAE	
	Campanula rotundifolia	

Major	Common	Occasional

Family - BORAGINACEAE

Cryptantha Fendeleri
Lithospermum canescens
Oreocarya glomerata

PLANTS OF THE JUNCUS COMMUNITY

Major	Common	Occasional
	Family - GRAMINEAE	
	Agropyron Smithii	Agrostis stolonifera
	Calamogrostis inexpansa	Calamovilfa longifolia
	Hordeum jubatum	Echinochloa crusgalli
	Poa palustris	Phleum pratense
	P. pratensis	
	Puccinellia Nuttalliana	
	Sphenopholis obtusata	
	Family - CYPERACEAE	
	Carex praegracilis	Carex atherodes
	Scirpus americanus	C. lanuginosa
		C. rostrata
		Eleocharis palustris
	Family - JUNCACEAE	
Juncus balticus		Juncus Dudleyi
		J. nodosus
		J. Torreyi
	Family - HALORAGIDACEAE	
	Hippuris vulgaris	
	Family - POLYGONACEAE	
	Polygonum lapathifolium	Polygonum coccineum
	P. scabrum	P. Convolvulus
	Rumex crispus	P. natans
	R. mexicanus	
	Family - SALICACEAE	
	Populus tremuloides	
	Salix spp.	

Major	Common	Occasional
	Family - RANUNCULACEAE	
	Ranunculus Cymbalaria	
	Family - ONAGRACEAE	
	Epilobium glandulosum	
	E. lineare	
	Family - ROSACEAE	
	Potentilla anserina	
	P. pennsylvanica	
	Family - LEGUMINOSAE	
	Glycyrrhiza lepidota	
	Family - COMPOSITAE	
	Achillea lanulosa	Crepis tectorum
	Artemesia gnaphalodes	Lactuca pulchella
	Bidens glaucescens	
	Brachyactis angusta	
	Cirsium arvense	
	Erigeron canadensis	
	E. philadelphicus	
	Senecio palustris	
	Solidago spp.	
	Sonchus arvensis	
	Taraxacum officinale	
	Family - LABIATAE	
	Lycopus asper	
	Family - CAMPANULACEAE	
		Campanula rotundifolia

PLANTS OF THE HORDEUM COMMUNITY

Major	Common	Occasional
	Family - JUNCAGINACEAE	
	Triglochin maritima	
	Family - GRAMINEAE	
Distichlis stricta	Alopecurus aequalis	Agropyron trachycaulum
Hordeum jubatum	Beckmannia syzigachne	Muhlenbergia asperifolia
	Puccinellia Nuttalliana	
	Spartina gracilis	
	Family - CYPERACEAE	
	Scirpus americanus	Scirpus paludosus
	Family - JUNCACEAE	
	Juncus balticus	
	Family - POLYGONACEAE	
	Rumex maritimus	Rumex crispus
	Family - CHENOPODIACEAE	
	Atriplex argentea	
	Chenopodium salinum	
	Salicornia rubra	
	Salsola pestifer	
	Suaeda depressa	
	Family - PRIMULACEAE	
	Glaux maritima	

Major	Common	Occasional
	Family - RANUNCULACEAE	
	Ranunculus Cymbalaria	
	R. sceleratus	
	Family - COMPOSITAE	
	Aster ericoides	
	Brachyactis angusta	
	Solidago spp.	
	Sonchus arvensis	
	Taraxacum officinale	
	Family - PLANTAGINACEAE	
	Plantago eripoda	
	Family - BORAGINACEAE	
		Heliotropium curassavicum

PLANTS OF DISTURBED PLACES (FIRE GUARDS, ROADWAYS, DAMS, ETC.)

Major	Common	Occasional
	Family - GRAMINEAE	
	Agropyron Smithii	Echinochloa crusgalli
	Bromus inermis	Hierochloe odorata
	Hordeum jubatum	Oryzopsis hymenoides
		Sporobolus cryptandrus
	Family - CHENOPODIACEAE	
	Axyris amaranthoides	
	Chenopodium album	
	Salsola pestifer	
	Family - POLYGONACEAE	
	Polygonum achoreum	
	P. aviculare	
	P. natans	
	Rumex crispus	
	R. venosus	
	Family - ARARANTHACEAE	
	Amaranthus retroflexus	
	Family - LEGUMINOSAE	
	Melilotus alba	Trifolium hybridium
	M. sativa	T. repens
	Family - CAPPARIDACEAE	
	Cleome serrulata	
	Family - CRUCIFERAE	
	Descurainia Sophia	Thlaspi arvense
	Lepidium densiflorum	

Major	Common	Occasional
	Family - COMPOSITAE	
Cirsium arvense	Artemesia frigida	Helianthus annuus
Iva xanthifolia	A. gnaphalodes	Lygodesmia juncea
	Erigeron canadensis	
	Grindelia perennis	
	Sonchus arvensis	
	Taraxacum officinale	
	Family - PLANTAGINACEAE	
	Plantago major	
	Family - SOLANACEAE	
	Solanum triflorum	

AQUATIC AND EMERGENT PLANTS OF FRESH WATERS

Major	Common	Occasional
	Family - LEMNACEAE	
	Lemna minor	
	Family - ZOSTERACEAE	
Potamogeton filiformis	Potamogeton Friezii	Ruppia occidentalis
P. pusillus	P. pectinatus	
P. Richardsonii	P. zosteriformis	
P. vaginatus	Zannichellia palustris	
	Family - CYPERACEAE	
Eleocharis palustris	Eleocharis acicularis	
	Scirpus americanus	
	S. validus	
	Family - TYPHACEAE	
	Typha latifolia	
	Family - HYDROCHARITACEAE	
	Elodea canadensis	
	Family - ALISMACEAE	
	Alisma gramineum	
	Family - HALORAGIDACEAE	
Myriophyllum exalbescens		
	Hippuris vulgaris	
	Family - CERATOPHYLLACEAE	
	Ceratophyllum demersum	

Major	Common	Occasional
	Family - CHARACEAE	
		Chara sp.
	Family - POLYGONACEAE	
	Polygonum lapathifolium	Polygonum natans P. scabrum Rumex mexicanus
	Family - RANUNCULACEAE	
	Rananculus subrigidus	
	Family - COMPOSITAE	
	Bidens glaucescens	

AQUATIC AND EMERGENT PLANTS OF SALINE WATERS

Major	Common	Occasional
	Family - ZOSTERACEAE	
	Potamogeton pectinatus	Potamogeton Richardsonii
	P. pusillus	
	P. vaginatus	
	P. zosteriformis	
	Zannichellia palustris	
	Family - CYPERACEAE	
	Eleocharis palustris	Scirpus nevadensis
	Scirpus americanus	S. validus
	S. paludosus	
	Family - TYPHACEAE	
	Typha latifolia	
	Family - ALISMACEAE	
	Alisma gramineum	
	Family - HALORAGIDACEAE	
Myriophyllum exalbescens		
	Family - CHARACEAE	
		Chara sp.
	Family - RANUNCULACEAE	
		Ranunculus subrigidus